FAA-E-2647
December 5, 1975

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
SPECIFICATION

CATEGORY III INSTRUMENT LANDING SYSTEMS

1. SCOPE AND CLASSIFICATION

1.1 Scope.- This specification defines the performance requirements and technical characteristics of a Category III Instrument Landing System that satisfies or exceeds the International Standards and Recommended Practices of Aeronautical Telecommunications, ICAO Annex 10. The specification covers the design, fabrication assembly, test and delivery of all subsystems and equipment that are required for a Category III Instrument Landing System. Electrical and mechanical specification details have been emphasized. The specification also includes requirements for: quality assurance, spare parts, special test equipment, special tools, documentation and equipment delivery. This specification will insure that minimum performance standards will be exceeded when the system is installed and operated at a field location.

The Category III Instrument Landing System design will include a Localizer subsystem, a Glide Slope subsystem, Marker Beacon subsystem, and a Remote Indication and Control subsystem. In normal Category III operation, the principal Localizer and Glide Slope transmitters will have redundant "hot standby" equipment units that are automatically connected to the antenna(s) if the principal transmitting equipment performance, as detected by internal or external executive monitoring sensing devices or circuits, exceeds specified limits thus, ensuring continued uninterrupted radiation of a satisfactory guidance signal. Triple parallel monitoring of each significant parameter will result in a reliable evaluation of the system. Any two alarms of monitored

parameters will result in a downgrade from Category III to Category I system status or from Category I to a system shutdown condition, depending upon the initial mode of operation. When the Category III course alignment tolerance is degraded, but is still within either Category I or II tolerances, the system will operate as a Category I system.

The Category III Instrument Landing System shall be capable of meeting stringent requirements for high integrity, continuity of service and reliability.

1.2 Classification.- This specification covers the following types of Category III Instrument Landing Systems:

Type I.	Category III Instrument Landing System consisting of a Localizer antenna group, a dual Localizer transmitting group with local triple monitoring and far field triple monitoring, a Glide Slope antenna group, a dual capture effect Glide Slope transmitting group with triple monitoring, and an inner, middle and outer marker beacon antenna group each instrumented with dual marker beacon transmitters, and a remote indication and control subsystem.
Type II.	Type I with a dual null reference Glide Slope transmitting group in place of the capture effect Glide Slope transmitting group.
Type III.	Type I with a maintenance monitor subsystem.
Type IV.	Type II with a maintenance monitor subsystem.

2. APPLICABLE DOCUMENTS

2.1 FAA Documents.- The following FAA specifications, standards and other publications, including all amendments thereto, and of the issue in effect on the date of contract award form a part of this specification to the extent specified herein. Where any discrepancies exist between this specification and the reference documents, this specification shall govern. Where any discrepancies exist between FAA documents and other reference documents, the FAA documents shall govern, unless otherwise specified.

2.1.1 FAA specifications.-

FAA-910	Structural Steel
FAA-G-1210	Provisioning Technical Documentation
FAA-C-1217	Electrical Work, Interior
FAA-C-1247	Erection of Self Supporting Towers
FAA-G-1375	Spare Parts - Peculiar for Electronic, Electrical and Mechanical Equipment

FAA-G-2100	Supplement 4, Electronic Equipment, General Requirements, FAA List of Applicable Documents
FAA-G-2100/1	Electronic Equipment, General Requirements, Part 1, Basic Requirements for all Equipments
FAA-G-2100/3	Requirements for Equipments Employing Semiconductor Devices
FAA-G-2100/4	Requirements for Equipments Employing Printed Wiring Techniques
FAA-G-2100/5	Requirements for Equipments Employing Microelectronic Devices
FAA-C-2256	Temperature and Humidity Control Equipment
FAA-D-2494/1	Instruction Books Manuscripts Technical: Equipment and Systems, Requirements, Part 1 - Preparation of Manuscript
FAA-D-2494/2	Preparation of Manuscript Copy and Reproducible Artwork

2.1.2 FAA standards.-

FAA-STD-002	Engineering Drawings
FAA-STD-003	Paint Systems for Structures
FAA-STD-016	Quality Control Program Requirements

2.1.3 Other FAA publications.-

FAA Advisory Circular 150/5345-2	Specification for L-810 Obstruction Lights
FAA Advisory Circular 70/7460-1	Obstruction Marking and Lighting
FAA Order 6750.16	Siting Criteria for Instrumentation Landing System
FAA Manual OA P 8200.1	United States Standard Flight Inspection Manual

2.2 Military and federal publications.- The following military and federal publications, of the issues in effect on the date of contract award, form a part of this specification and are applicable to the extent specified herein. Where any discrepancies exist between military and federal publications and other publications other than FAA documents, the military and federal publications shall govern, unless otherwise specified.

2.2.1 Military specification.-

MIL-D-1000	Drawings, Engineering and Associated Lists
MIL-E-17555	Packaging & Packing of Electronic & Electrical Equipment, Accessories & Repair Parts
MIL-F-16061	Fans, Ventilating, Propeller
MIL-I-45208	Inspection Systems Requirement

2.2.2 Military handbook.-

MIL-HDBK-217	Reliability Stress and Failure Rate Data for Electronic Equipment

2.2.3 Military standards.-

MIL-STD-470	Maintainability Program Requirements
MIL-STD-471	Maintainability Demonstration
MIL-STD-756	Reliability Prediction
MIL-STD-781	Reliability Testing
MIL-STD-785	Reliability Program

2.2.4 Federal specifications.-

L-P-383	Plastic Material, Polyester Resin, Glass Fiber
SS-T-312	Base, Low Pressure Laminated Floor, Asphalt, Rubber, Vinyl, Vinyl Asbestos
RR-S-001301	Safety Equipment, Climbing

2.2.5 Federal standards.-

Federal Standard 595 Colors

2.3 Other publications.- The following publications, of the issue in effect on the date of contract award forms a part of this specification and are applicable to the extent specified herein.

2.3.1 ASTM standards.-

ASTM E 84	Surface Burning Characteristics of Building Materials
ASTM B 136	Noncombustibility of Material

ASTM D 635	Flammability of Rigid Plastics
ASTM D 1962	Flammability of Plastic Foams and Sheeting

2.3.2 Other documents.-

ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers Guide and Data Book
Uniform Building Code Volume 1	International Conference of Building Officials
IES Handbook	Illuminating Engineering Society
ICAO Annex 10	International Standards and Recommended Practices, Aeronautical Telecommunications, International Civil Aviation Organization
OSHA	Occupational Safety and Health Standards U.S. Department of Labor
EIA Standard RS-222-A	Structural Standards for Steel Antenna Tower and Antenna Supporting Structures
UFPA No. 70	National Electrical Code

Copies of this specification and other applicable FAA specifications, standards, directives, advisory circulars and drawings may be obtained from the Contracting Officer in the Federal Aviation Administration Office issuing the invitation for bids or request for proposals. Requests should fully identify materials desired, i.e., specification, standard, amendment and drawing numbers and dates of issue. Requests should cite the invitation for bids, request for proposals, or the contract involved or other use to be made of the requested material. Information on obtaining copies of Federal specifications and standards may be obtained from General Services Administration offices in Atlanta, Auburn, Washington, Boston, Chicago, Denver, Fort Worth, Kansas City, MO, Los Angeles, New Orleans, New York, San Francisco, and Washington, D. C.

Single copies of military standards and specifications may be requested by mail or telephone from the U.S. Naval Supply Depot, 5801 Tabor Avenue, Philadelphia, PA 19120 (for telephone requests call 215-687-3321, 8 AM to 4:30 PM, Monday through Friday). Not more than five items may be ordered on the same request. The applicable invitation for bids or contract number should be cited.

Information on obtaining copies of the National Electrical Code may be obtained from the National Fire Protection Association, 60 Batterymarch Street, Boston, Massachusetts 02110.

Copies of ASTM standards may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

Information on obtaining copies of the EIA standard may be obtained from the Electronic Industries Association, Engineering Department, 200 I Street, N.W., Washington, D. C. 20006.

Information of obtaining copies of the IES Handbook may be obtained from the Illuminating Engineering Society, 1860 Broadway, New York, NY.

Information of obtaining copies of the ICAO standard may be obtained from the International Civil Aviation Organization, P. O. Box 400 Succursale: Place de l'Aviation Internationale, 1000 Sherbrooke Street, West, Montreal, Quebec, Canada H3A 2R2.

Information on obtaining copies of the ASHRAE Guide and Data Book may be obtained from the American Society of Heating, Refrigerating and Air Conditioning Engineers, 345 East 47th St., New York. NY 10017.

Information on obtaining copies of the Uniform Building Code may be obtained from the International Conference of Building Officials, 50 South Los Robles, Pasadena, California 91101.

3. REQUIREMENTS

3.1 Equipment to be furnished by the contractor.- The following items of equipment shall be furnished as specified in the invitation for bids or request for proposals. In addition, any equipment, part or device necessary for proper operation of the system shall be furnished by the contractor even though that equipment, part or device may not be specifically provided for or described herein.

Item No.	Description	Reference Paragraph
1	VHF Localizer Subsystem	3.5
2	UHF Glide Slope Subsystem	3.6
3	VHF Marker Beacon Subsystem	3.7
4	Remote Indication and Control Subsystem	3.8
5	Maintenance Monitor Subsystem	3.9

3.2 Definitions.- The following series of definitions define nonstandard technical terms and/or special terms that form a part of this specification and are descriptive of the Category III Instrument Landing System.

Instrument Landing System (ILS) categories.- Category III ILS - equipment capable of providing acceptable guidance information from the coverage limit (at least 18 miles) of the facility to, and along, the surface of the runway.

Category II ILS - Equipment capable of providing acceptable guidance information from the coverage limits of the facility to the point where the Localizer course line intersects the glide path at a height of 15 meters (50 ft.) or less above the horizontal plane containing the runway threshold.

Category I ILS - Equipment capable of providing acceptable guidance information from the coverage limits of the facility to the point at where the Localizer course line intersects the glide path at a height of 30 meters (100 ft.) or less above the horizontal plane containing the runway threshold.

Threshold - That point along the ILS runway which is considered to be the beginning of the usable runway pavement.

Difference in depth of modulation (DIM). The percentage of modulation depth of the larger signal, minus the percentage of modulation depth of the small signal, divided by 100.

Course line - The locus of points nearest the runway centerline in any horizontal plane at which the DDM is zero.

Localizer course sector - A sector in the horizontal plane containing the course line and limited by the loci of points nearest the course line along which the DDM is 0.155.

Sum of depth of modulation (SDM) - The sum of the percentages of modulation.

Displacement sensitivity - The ratio of change in DDM of a guidance signal to the displacement (in the guidance plane being considered) that produced the change.

Glide path - The locus of points in a vertical plane containing the runway centerline along which the DDM is zero and which, of all such loci, is at the desired glide path angle (θ).

Glide path angle (θ) - The angle between a straight line representing the mean of the ILS glide path and the horizontal.

Glide path sector - The sector in the vertical plane containing the glide path and limited by the loci of points nearest to the glide path at which the DDM is 0.175.

Half glide path sector - The sector in the vertical plane, containing the glide path and limited by the loci of points nearest to the glide path at which the DDM is 0.0875.

Power output - The average power supplied by the carrier plus navigational modulation components, referenced at the output of the transmitter that interfaces with the antenna group feeder cables.

Mean power - The power supplied at the RF module output during normal operation, averaged over a time sufficiently long compared with the period of the lowest frequency encountered in the modulation. A time of 1/10 second during which the mean power is greatest will be selected normally.

Carrier modulation balance - The term "carrier modulation balance" is defined by, and will exist when the following conditions prevail at the carrier output:

(a) Unity ratio between 90 Hz upper and lower sideband signal levels.

(b) Unity ratio between 150 Hz upper and lower sideband signal levels.

(c) Unity ratio between the total 90 Hz upper and lower sideband signals and the total 150 Hz upper and lower sideband signals.

(d) Pure amplitude modulation only, with no frequency or phase modulation components.

The above conditions result in zero DDM at the carrier output.

Sideband balance - The term "sideband balance" is defined by, and will exist when the following conditions prevail at the sideband output.

(a) Unity ratio between 90 Hz upper and lower sideband signal levels.

(b) Unity ratio between 150 Hz upper and lower sideband signal levels.

(c) Unity ratio between the total 90 Hz upper and lower sideband signals and the total 150 Hz upper and lower sideband signals.

Total modulation balance - The term "total modulation balance" is defined by, and will exist when, the following conditions prevail:

(a) Carrier modulation balance

(b) Sideband balance

Sideband ratio - The ratio of the total (90 Hz and 150 Hz) sideband power delivered at the carrier output, to the total (90 Hz and 150 Hz) sideband power delivered at the sideband output.

Stray radiation - The emission or leakage of the fundamental frequency signals from the equipment at points other than from the normal output(s).

Spurious radiation - An emission on frequency or frequencies which are outside the necessary band and the level of which may be reduced without affecting the corresponding transmission of information. Spurious radiations include harmonic emissions, parasitic emissions, hum, noise and intermodulation products, but exclude emissions in the immediate vicinity of the necessary band which are a result of the modulation process for the transmission of information.

Standard glide slope signal - An RF carrier amplitude modulated simultaneously with 90 Hz and 150 Hz signals so that the sum of their separate modulation percentages equals 80 percent with the voltage waves of the 90 Hz and the 150 Hz signals simultaneously passing through zero in the same direction each 1/30 second.

Standard localizer signal - An RF carrier amplitude modulated simultaneously with 90 Hz and 150 Hz signal so that the sum of their separate modulation percentages equals 40 percent with the voltage waves of the 90 Hz and 150 Hz signals simultaneously passing through zero in the same direction each 1/30 second.

ILS reference datum - A point determined by the intersection of the downward extended straight line glide path with a vertical line that passes through the runway centerline at the threshold.

Single-frequency (Null Reference) glide slope configuration - A Glide Slope design in which the guidance signal is provided by a single RF carrier. The desired on-path angle corresponds with the first sideband null of the vertical radiation pattern.

Two-frequency (capture effect) configuration - A Localizer or Glide Slope design in which the guidance signal is provided by two RF carriers lying within the same receiver channel but sufficiently spaced in frequency that their difference frequency falls outside the receiver's audio passband. One of these carriers provides a narrow-beam, high-accuracy guidance signal while the other carrier provides a lower power clearance signal outside the limits of coverage of the guidance signals.

Failure - The inability of any part, circuit, assembly, unit or group of the ILS to operate within its normal and previously established operating tolerances shall constitute a failure. It shall be specifically noted that it is not necessary that a maintenance action be required or a station outage result to qualify as a failure. The location of a failure shall not be a valid criterion for establishing its relevance.

Interlock - The means for effecting the necessary switching functions to rapidly change from one system to the other at those locations having Instrument Landing Systems on the opposite end of a single runway and prevents simultaneous equipment operation.

Module - A "module" is defined as being two or more basic parts which form a functional assembly which is a portion of a larger assembly or unit. The module is easily removed intact and replaced by plug-in, unsoldering, "quick-disconnect" fastener or equivalent means. It may or may not contain printed circuitry and it may contain active or passive devices.

Equipment group - An "equipment group" is defined as being two or more assemblies or units. The equipment groups combine to form a subsystem.

ILS facility reliability - The probability that an ILS ground installation radiates signals within the specified tolerances.

3.3 Reserved

3.4 General ILS Category III equipment requirements

3.4.1 Design considerations.- The design and construction of the equipment provided as part of the Category III ILS shall have an expected operational life of 15 years. The engineering practices and requirements specified in FAA specifications, FAA-G-2100/1, FAA-G-3100/3, FAA-G-2100/4, FAA-G-2100/5 and supplement 4 of the FAA-G-2100 series are applicable in the design and manufacture of the Category III ILS. The materials, components and subassemblies shall satisfy the applicable requirements as stated in the D.O.D. index of specifications and standards and shall be procured from qualified suppliers that are currently on the Qualified Producers List of the Department of Defense. In addition, as a minimum, all components and design practices shall satisfy the following requirements:

3.4.1.1 Modular construction.- The ILS design shall make maximum use of sealed components and easily removable plug-in module assemblies containing one or more related circuits. The design of the modules shall permit disassembly of the module for maintenance or repair.

3.4.1.2 Printed wiring boards.- All printed wiring boards shall be in accordance with FAA-G-2100/4 with the exception that all electrical-connection holes in the printed wiring boards and cards shall be of the plated through hold or eyelet type. The boards shall be plug-in type with suitable guides and shall be keyed such that they can be inserted only in the correct receptacle and in the correct orientation.

3.4.1.3 Preferred Components.- Components built to Defense Department MIL standards and specifications shall be utilized where practical. Values of capacitors and resistors shall be selected from EIA preferred values with ± 10 percent tolerance, except for components requiring closer tolerances as, for example, metering shunts or multipliers.

3.4.1.4 Special Selection of Components.- Special selection of transistors, semi-conductors, resistors, capacitors, and other similar components within the same type designation will not be permitted. Circuit design shall be such that the performance objectives of this specification are met by using any replacement component of the same type and model considered by its manufacturer to be normal, within allowable tolerance, and representative of the statistically variable parameters under which they are manufactured.

3.4.1.5 Solid-state design.- All active electronic devices shall be semiconductor devices in accordance with FAA-G-2100/3 or microelectronic devices in accordance with FAA-G-2100/5. Transistors and semiconductors employed shall be selected from government-approved, manufacturer's preferred type lists. A minimum number of types of transistors, and semiconductors shall be employed, consistent with achieving the design objectives of this specification, and they shall be sufficiently derated to assure meeting the reliability requirements of this specification for all probable environmental conditions.

3.4.1.6 Derating of Components.- All resistors, fixed and variable, shall be operated at 50 percent power-derating. All capacitors shall be operated at 50 percent voltage-derating, unless a written waiver is obtained from the FAA.

3.4.1.7 Capacitors.- Electrolytic capacitors shall not be used without specific approval by the FAA.

3.4.1.8 Rectifiers.- Wherever possible, rectifiers shall be of the silicon solid-state type. Adequate surge-protection against transients shall be provided. Adequate cooling shall be provided to permit continuous duty operation under all operating conditions.

3.4.1.9 Light bulbs.- All incadescent light bulbs used as indicator devices in the ILS shall be designed for a minimum average operating life of 5,000 hours.

3.4.1.10 Assembly Techniques.- Small components, such as carbon resistors, mica capacitors, and diodes, shall be mounted on parts boards unless circuit requirements dictate otherwise.

3.4.1.11 Accessibility.- All assemblies, subassemblies, modules and test points that may require servicing, repair, or replacement shall be readily accessible and shall have sufficient clearance from shelter walls for easy access for maintenance. Major assemblies shall be completely removable from their enclosures without disassembly. Access shall be provided to modules from outside the basic equipment through the use of swing-out chassis or pull-out drawers having slides with mechanical stops such that no strain is placed on connecting cables or disconnect plugs, or equivalent devices; cable retractors and circuit extenders shall allow component or module operation in the open position.

A board extractor and extender boards or cables, as applicable, shall be furnished in a suitable storage space within the equipment. In lieu of a board extractor, handles may be provided on each printed wiring board. A minimum of one extender for each type of receptacle shall be furnished at each facility. Extenders are intended for the accomplishment of detailed trouble-shooting only. Normal functional checks and adjustments of the equipment shall be possible through the provision of significant test points, meter outputs, controls or other means which are readily accessible without resort to extenders, thereby allowing testing without interruption of operation.

Mechanical units within an assembly should have the capability of being disassembled and reassembled in the field without the use of special tools, jigs and/or fixtures. If special devices are required for assembly, disassembly or reassembly, they shall be provided by the contractor.

3.4.1.12 Interchangeability.- Due to the high degree of commonality in the functional characteristics between subsystems, assemblies and subassemblies, all equipment provided as part of the Category III ILS shall be designed and constructed to the maximum advantage of modular interchangeability with a minimum of adjustment and/or recalibration.

3.4.1.13 Test points and test facilities.- The design shall incorporate indicators, warning signals, test jacks and test points as necessary to facilitate trouble shooting and malfunction isolation to the optimum functional level. Test points shall be provided to check essential waveforms and voltages and for the injection of test signals. The test points shall be strategically located for easy accessibility. Their locations shall be kept to a minimum and each shall be labeled for easy identification and reference to maintenance data and designed for easy attachment of test probes and test equipment. Test points providing connections to circuits containing rf potentials or to circuits that require shielded or coaxial cable to prevent interaction by external signals, shall use type BNC connectors for the test point connection. Where extender boards are required for adjustment, testing or maintenance, they shall be furnished as part of the equipment.

3.4.1.14 Controls.- Controls that are essential to the proper operation or periodic maintenance of the equipment, or other controls that are in frequent use on the various assemblies or panels, shall have scale marking to facilitate return of the control to a predetermined position. All critical tuning controls shall include locking devices. It shall not disturb the setting to lock or unlock the control. All controls shall be clearly marked as to function and maintenance data reference symbol.

3.4.1.15 RF power metering.- Each VHF localizer station, VHF glide slope station, and marker beacon station shall be provided with built-in line sections, with metering jacks, which will accept standard Bird Electronic Corporation Wattmeter elements (not to be supplied under this specification), for the measurement of RF power levels. The metering jack of each line section shall be connected through a selector switch to a waveform jack and meter. The meter shall be panel mounted in each facility. The accuracy of the power level indications shall be within ± 5 percent of full scale meter readings.

3.4.1.16 Test meters.- A meter, meters, or other indicators shall be provided to allow convenient monitoring of operational parameters required for initial equipment turn-up, preventive and corrective maintenance.

3.4.1.17 Flammable Materials.- Flammable materials shall be in accordance with FAA-C-2100/1.

3.4.1.18 Toxic Materials.- Toxic materials, or those giving off toxic or pungent fumes shall not be used.

3.4.1.19 Finish and Color.- Colors of the ILS localizer and glide slope shelter exterior surfaces shall be checkerboard or alternate vertical bands aviation orange, color 12197, and insignia white, color 17875, in accordance with FED-STD-595. The shelter interior shall have a semi-gloss or flat surface finish of off-white or beige to present a light pleasant environment. The color of the floor tile shall be complimentary to the interior finish. Glide slope antenna towers and localizer antenna supports shall be painted in an obstruction marking configuration. The exterior surface of the marker beacon shelter shall be insignia white, color 17875 of FED-STD-595. All painting shall be in accordance with FAA-STD-003, unless otherwise indicated. Wood poles shall not be painted.

3.4.1.20 Induced Transients Protection.- The equipment shall be designed to adequately withstand without damage or operational upset induced transients appearing on any input subsystems of, power, control and monitor lines, such as caused by lightning. For this purpose, protection shall be provided for transients of the following characteristics.

Amplitude: 1000 V, both positive and negative

Risetime: 10 microseconds

Decay time: Exponential to half amplitude in one millisecond

3.4.1.21 Antenna support material and design.- The VHF marker beacon antenna support shall be a water-borne preservative full length treated Class 1 wood pole meeting or exceeding the requirements set forth in FAA specification FAA-E-113 or it shall be a self-supporting steel tower. The counterpoise Structure, if used, shall be constructed of steel. Glide slope antenna supports shall be self-supporting steel towers. Localizer antenna element supports shall be of steel or aluminum and the complete antenna array shall be designed for installation on a ground mounted support or on an elevated platform support. The antenna array support structure (elevated or ground mounted) is not to be furnished under this specification. Heights of poles, towers and platforms shall be as indicated in the antenna requirements set forth herein. The design wind loads, manufacture and workmanship, factory finish, plans and markings, foundation design and protective grounding for steel towers and supports shall be in accordance with EIA Standard RS-222-A and FAA specifications FAA-910 and FAA-C-1247, unless otherwise indicated herein. All steel members, including hardware, shall be hot dip galvanized after fabrication. Foundations shall be designed for a soil pressure of 3,000 lbs. per square foot. Quality assurance shall be in accordance with paragraph 4 of this specification. Design, fabrication and erection drawings, specifications and design analysis for metal towers and typical platform including the foundation shall be furnished in accordance with paragraph 3.4.10.33 comparable to that for the shelters.

3.4.2 Test equipment requirements

3.4.2.1 Test equipment general requirements.- The Category III ILS design shall incorporate those test points, test facilities (internal test equipment) and specific purpose test equipment (external) that are necessary to initially activate the system at a field location, perform operational evaluation of the system equipment, and perform normal maintenance of all equipment. This requirement shall be in accordance with FAA-G-2100/1, paragraph 1-3.18. In addition, the system contractor shall prepare and deliver to the FAA a general test equipment list that includes all of the test equipment that is required to satisfy this specification.

3.4.2.2 Built-in test equipment.- The system design shall include test points and built-in test equipment necessary to achieve and maintain the performance characteristics specified for all Category III operational equipment. Special purpose test equipment shall be held to a minimum. It shall be possible with the aid of built-in test points and special purpose test facilities, which can be supplemented with regular commercial test equipment, to evaluate (test) and perform all adjustments necessary to initially tune, calibrate and maintain the Category III ILS equipment. All test points and built-in test facilities shall be considered part of the system and shall be deliverable as part of the Category III ILS.

3.4.2.3 Special test equipment.-All test equipment of a special purpose nature that is not built-in to the system and is not available through regular commercial channels and is necessary to initially activate, tune, calibrate and maintain the Category III ILS equipment shall be provided as part of the deliverable system. This equipment shall include all interface and mounting devices necessary to perform all tests, alignment and maintenance activities.

3.4.2.4 General purpose test equipment.- The general purpose test equipment that is not built-in to the Category III ILS or is not of a special purpose nature support equipment, need not be provided as part of the deliverable system. Any test equipment of a general purpose type that is required and necessary to activate, tune, calibrate, or maintain the system equipment shall be documented as specified in 3.4.2.5.

3.4.2.5 Test equipment list.- A general test equipment list shall be prepared and delivered to the FAA identifying all test equipment and interface devices that are not built-in to the system equipment and that are necessary to activate, tune, calibrate, and maintain the Category III ILS equipment. This list shall segregate special purpose and general purpose test equipment devices. It shall identify all equipment according to source of manufacture or recommended manufacture, model/part number or recommended model/part number, National stock number, approximate value and required utilization in support of the Category III ILS equipment. If the special purpose equipment or devices do not have a manufacturer's model or part number, the manufacture drawing number that was utilized to manufacture this equipment or device shall be utilized.

3.4.3 Special tools and equipment

3.4.3.1 Special tools and equipment requirement.- The contractor will identify and provide, as part of the Category III ILS, all special tools and special equipment items that are required to install, activate, tune, calibrate, maintain and overhaul major subsystems and the equipment within a subsystem. This requirement does not include generally available installation or maintenance tools or equipment that are available through regular commercial sources. The requirements of FAA-G-2100/1, section 1-3.16.23 shall apply to the special tools and equipment requirements.

3.4.3.2 Special tools and equipment list.- The contractor shall propose and deliver to the FAA a general list of tools and equipment items that are necessary to support the implementation and operations of the Category III ILS. This list shall identify both the special tools and equipment items delivered as part of the Category III ILS as well as those general purpose tools and equipment items not delivered, but are required to implement and operate the system. The list shall identify the tool or equipment item,

its manufactured or recommended manufacturer, the model number or recommend model number, the National stock number, estimated value, and utilization in support of the implementation or operation of the Category III ILS. Any tool or equipment item that cannot be identified by manufacturer and model will be identified by the manufacturer's drawing number.

3.4.4 Spare parts requirements

3.4.4.1 Site spare parts.- Each ILS subsystem shall include one spare printed circuit board (complete with all components tested and operable) and one spare module of each type used in the subsystem. This requirement is in addition to any spare parts required to be supplied under Specification FAA-G-1375.

3.4.5 Maintainability.- The Category III ILS, subsystems shall be designed and constructed to possess a mean-time-to-repair (MTTR) for single failure of 0.5 hour, and have a maximum repair time (MRT) of 1.5 hours (95th percentile). The repair times given above include: diagnostic time, disassembly and removal of the equipment item or component that has failed, replacement and installation of a new equipment item or component, and all adjustments necessary to place the equipment and/or subsystem in normal operation. Mean-preventive-maintenance-time (MPMT) of any complex configuration of any subsystem that comprises the Category III ILS shall not exceed one hour in 336 hours of operation, including inspection and checks to assure performance. Ninety-five percent of all routing procedures shall be accomplished in less than 15 minutes. No single group of periodic procedures shall require more than two-hours time or be required more frequently than every 2000 hours. Any parts or components requiring preventive maintenance, as well as system checks not revealed by a monitor, shall be specified by the supplier with recommended maintenance and replacement intervals. No failed component shall require more than 8 hours for repair at the depot level. This shall include all operations from fault isolation to test after repair.

3.4.6 Reliability.- The equipment provided as part of the Category III ILS shall be designed for continuous operation with a minimum of down time. Particular attention shall be paid to the derating of components so that they represent a negligible portion of the repair and overhaul. The MTBF is required of the following major subsystems:

3.4.6.1 Localizer subsystem reliability.- The Localizer subsystem shall be designed such that given a fully operational Localizer the theoretical probability of a potentially hazardous signal fault including loss of signal during any 10-second period shall not exceed 0.75×10^{-7} due to equipment failure. The specified MTBF for the serial reliability model of the Localizer subsystem shall be not less than 2500 hours. A potentially hazardous signal is defined as radiation outside the tolerance of the monitor limits.

3.4.6.2 Glide Slope subsystem reliability.-The Glide Slope subsystem shall be designed such that given a fully operational Glide Slope the theoretical probability of a potentially hazardous signal fault including loss of signal during any 5-second period shall not exceed 0.50×10^{-7} due to equipment failure. A potentially hazardous signal is defined as radiation outside the tolerance of the monitor alarm limits. The specified MTBF for the serial reliability model of the Glide Slope subsystem shall be not less than 4000 hours.

3.4.6.3 Marker Beacon subsystem reliability.- The specified MTBF for the serial reliability model of the Marker Beacon subsystem shall be not less than 10,000 hours.

3.4.6.4 Remote Indication and Control Subsystem reliability.- The specified MTBF for the serial reliability model of the Remote Indication and Control subsystem shall be not less than 12,000 hours.

3.4.6.5 Maintenance Monitor subsystem reliability.- The specified MTBF for the serial reliability model for the maintenance monitor subsystem shall be not less than 12,000 hours.

3.4.7 Prime and Standby Power.- The Category III ILS, subsystems and equipment shall be designed to operate from a primary power source having the following characteristics:

(a)	Voltage	120/240 volts single phase, three-wire AC line
(b)	Frequency	57 to 63 Hz
(c)	Regulation	15%

Standby battery power shall be furnished from a continuously engaged or floating battery power supply. The standby power source shall permit continued normal subsystem operation for a period of at least three (3) consecutive hours for the Localizer (excluding far field monitor) and Glide Slope subsystems and seventy-two (72) consecutive hours for the Marker Beacon subsystem and localizer far field monitor, with battery temperature derated to 0 degrees C under the specified service conditions. A trickle charger shall maintain the batteries in operational readiness and shall restore them to full charge from a 50 percent discharge condition within 8 hours of primary power restoration, for the localizer and glide slope subsystem and 24 hours for the marker beacon subsystem and localizer far field monitor while maintaining system operation. Ancillary functions not contributing directly to the guidance signal shall not be required to operate on standby power. Additionally, the equipment shall meet all specification requirements with or without batteries installed.

The design of all prime power sources shall utilize grounding practices which will assure stable, controllable performance within required limits under all stated environmental conditions including power line transients and mechanical vibration. A single common ground shall be utilized for each subsystem.

3.4.7.1 Voltage regulators.- External voltage regulating transformers shall not be used with this equipment. Voltage regulation in the equipment shall be provided (if required) by means of voltage or current regulators, or both, in the DC output circuit of the power supplies.

3.4.8 Electromagnetic interference.-The Category III ILS shall be designed to meet the applicable type acceptance criteria of the Federal Communications Commission (FCC) in accordance with paragraph 1-3.17 of Specification FAA-G-2100/1. Each subsystem shall be designed so that the mean power of spurious RF emission supplied to the antenna transmission line shall be at least 60 dB below the mean power of the fundamental. With each transmitter terminated into a dummy load or a properly terminated cable, the stray radiation of any frequency from the equipment under any operating conditions shall not exceed 5.0 microwatt (marker beacon 1.0) effective radiated power (ERP).

3.4.9 Environmental requirements.- All subsystems and equipment that comprise the Category III ILS shall be designed and manufactured to meet the applicable environmental service conditions that are specified in FAA-G-2100/1, Electronic Equipment, General Requirements as well as the following additional requirements:

3.4.9.1 Altitude.- When not operating all equipment shall be capable of withstanding, without visible or electronic damage, an altitude of up to 50,000 feet.

3.4.9.2 Solar Radiation.- All equipment installed outdoors shall be capable of operating to specification when subjected to solar radiation of 350 BTU per square foot per hour at any angle of incidence.

3.4.9.3 Salt Atmosphere.- Outdoor equipment shall be capable of operating within specified performance requirements under salt spray conditions.

3.4.9.4 Corrosive Atmosphere.- Outdoor equipment shall be capable of operating within specification performance requirements under the influence of industrial corrosive atmosphere.

3.4.9.5 Fungus.- No fungus nutrient materials shall be utilized in manufacture of any equipment delivered to this specification.

3.4.9.6 Sand and Dust.- All equipment shall be protected from penetration or abrasive damage by sand and dust and from overheating caused by the insulation of cooling surfaces or forced air ventilating ducts by the accumulation of dust.

3.4.9.7 Rainfall.- All equipment installed outdoors shall be capable of surviving without degradation a rainfall rate of 4 inches/hour or an accumulated rainfall of 80 inches in any year.

3.4.9.8 Hail.- All equipment installed outdoors shall have the capability of surviving without degradation hail stones 1/2 inch in diameter.

3.4.9.9 Seismic.- All subsystems and equipment shall be designed and manufactured to survive without degradation under Zone 3 of the Uniform Building Code.

3.4.10 Shelters

3.4.10.1 Equipment to be furnished.- Localizer, glide slope and marker shelters shall be furnished by the contractor, complete, and in accordance with all requirements herein. One building each shall be furnished for each localizer, each glide slope, and each marker. Quantities to be furnished are as specified in the contract schedule.

3.4.10.2 Interfaces.- The contractor shall design and provide all conduit, power wiring, electrical power distribution panels, junction boxes, ground fault interrupters and supporting hardware required to provide a complete operable interface between the shelter and the antenna group.

3.4.10.3 General.- The ILS shelters described herein will be located on or adjacent to airports throughout the United States and may be installed as close as 200 feet from active jet runways. The shelters will be used to house (a) contractor furnished electronic equipment, (b) ancillary electrical, mechanical, and support items furnished by the contractor, and (c) additional items to be installed by the Government at a later date in space to be designated therefore by the contractor. The shelters shall be designed for an intended useful life of 20 years, and shall be structurally capable of relocations without major repair. Exterior maintenance for the first 20 years shall be limited to minor repairs and caulking. Interior maintenance shall be limited to cleaning, minor repairs, and light bulb replacement during the normal functional operation of the facility for the useful 20-year life. Repainting and re-roofing shall not be required. The structural design, material selection, foundation design, and protective finishes shall comply with current good engineering practice and, in addition, meet or exceed the engineering requirements stated. The shelters shall be designed in accordance with the Uniform Building Code (UBC), Volume 1, current edition, the National Electric Code (NEC), latest edition, and shall comply with the applicable rules and regulations of Occupational Safety and Health Administration (OSHA), Title 29, Chapter XVII, Part 1910.

The contractor shall lay out, design, fabricate, and furnish shelters suitable to house all the components, including electronic equipment, electrical/mechanical equipment, storage facilities, work surfaces, batteries, etc., required for the complete ILS system. The shelter and electrical/mechanical equipment with or without installed electronic equipment shall be designed for transportation from the equipment contractor's plant to the installation site and future transportation to different locations by the Government. The slide out drawers of electronic equipment, the air conditioner and wall opening hood covers may be packed in separate cartons and stored in the shelter for shipment. If any wall openings are thus exposed, then they shall be tightly covered and sealed with suitable materials for shipment and possible long term storage. Other long term storage provisions, as required, including appropriate instructions shall be provided.

3.4.10.4 Standard localizer and glide slope layouts.- The layout of equipment in the shelters shown in Figure 7 is a typical arrangement. The sketch is included herein to illustrate the general scope and relationships on an overall layout and serve as a base for the development and evaluation of the contractor's final layout. The contractor is encouraged to propose changes and improvements to the layout commensurate with final equipment configuration and state-of-the-art technology. The following is applicable to the localizer, glide slope and marker beacon shelters.

(a) Working space.- A 30 inch clear work area shall be maintained in front of all electronic equipment, as well as work benches, storage cabinets and electrical and mechanical equipment.

(b) Fire extinguishers.- Space shall be provided near the building door for placement, by the Government, of a wall mounted 15 lb. CO_2 fire extinguisher plus a 2 1/2 gallon soda-acid or water type or a 10 lb. multi-purpose dry chemical type fire extinguisher.

(c) Work benches and storage cabinets.- The localizer and glide slope shelters shall be provided with a laminated maple top, steel frame, work bench with minimum dimensions of 24" x 48" x 36" and a steel storage cabinet with adjustable shelves. The marker shelters shall be provided with a laminated maple top, steel frame, work bench with minimum dimensions of 24" x 36" x 36" and a steel storage cabinet with a minimum storage capacity of at least six cubic feet. Three copies of the proposed layout of shelter, equipments, and siting shall be submitted to the Contracting Officer or his designated Technical Representative for approval. The interior layouts shall include all electronic and electro/mechanical equipment, power distribution panels, battery boxes, junction boxes and ductwork. Interior elevations shall be included, as necessary, to show wall mounted items and openings. The site layout shall include foundations; all underground and overhead conduit and cables; relationship of the shelter and the antenna; and space requirements for

construction, erection, and installation of the shelters. All dimensions necessary for the evaluation of layouts shall be included.

3.4.10.5 Service conditions.- The shelters and the equipment therein shall sustain the maximum stresses by the specified service conditions without permanent deformation, damage or degradation of operation.

3.4.10.6 Shape and size.- The localizer and glide slope shelters shall be rectangular in shape with nominal exterior dimensions of 8 feet 0 inches by 12 feet 0 inches. The marker shelter shall be rectangular in shape with nominal exterior dimensions of 6 feet 0 inches by 8 feet 0 inches. To facilitate over-the-road transportation, the maximum clear width of the shelters shall not exceed 8 feet 0 inches, including minor protuberances such as door knobs. The shelters, including small nonremovable roof mounted appurtenances (see paragraph 2-3.5.2.9), when loaded for over-the-road transport, shall pass through a highway underpass having a clearance of 13 feet 6 inches with a minimum clearance of 3 inches. The shelter wall thickness shall not exceed 5 inches. The minimum interior floor-to-ceiling height shall be 8 feet 0 inches or 2 feet 0 inches higher than the equipment racks, whichever is greater. The minimum interior head clearance (personnel safety) shall be 6 feet 4 inches in work areas.

3.4.10.7 Design criteria.- The localizer and glide slope shelters shall be designed in accordance with the Uniform Building Code, Volume 1, current edition. This specification shall take precedence over the Uniform Building Code in event of conflict. The shelters shall be skid mounted and designed to withstand subsequent relocations, with all equipment in place, after initial field installation. The shelters shall be in accordance with all applicable requirements of Department of Labor Standard Title 29, Chapter XVII, Part 1910. The shelter, including roof, shall be designed and connected to the floor structure so the structure as a whole shall be capable of resisting twice the overturning moment resulting from wind uplift forces stipulated with the floor structure anchored to the foundation. The structural design shall incorporate all requirements for openings and support made necessary by equipment installed in, on, or through the structure. Floor, wall, and roof surface materials shall not be used for support, restraint, or alignment of installed equipment. The floor system shall be designed to support a uniform live load based upon the maximum loads imposed by the equipment and personnel to be supported, recognizing that electronic equipment may be relocated within the shelter in the future. In no case shall the floor be designed for less than 40 p.s.f. The floor system deflections due to equipment loading and

live loads of 150 p.s.f. shall not exceed 1/360 of the spans. The ceiling shall be designed to support a uniform live load based upon the maximum loads imposed by equipment mounted or suspended from the ceiling. Design loads shall be based on the service conditions of paragraph 3.4.9. The shelter shall be designed to withstand the dynamic loads resulting from sudden starting and stopping during transportation and movement over bumpy roads with all equipment in place. The dead load of the shelter and all installed equipment shall be included in the dynamic design. The minimum vertical shock loading shall be 3 g and the minimum lateral and longitudinal shock loads shall be 1g. Shock loads shall be considered to have a maximum frequency of 20 Hz.

3.4.10.8 Materials and material application.- Materials of construction shall be suitable for the intended application considering the shelter life, service conditions, and transportation loads. The ultimate sites for these shelters may range from coastal environments with salt atmosphere to mountainous areas. Provisions shall be made for prevention of corrosion; avoidance of unprotected faying surfaces, moisture traps, and galvanic couples due to contact between dissimiliar metals; and proper selection and application of protective finishes. The shelter design shall keep maintenance to a minimum during the life of the shelters with no required periodic maintenance inspection or activity normally necessary more often than once every three months.

3.4.10.9 Fire resistance.- Materials used for shelter construction (hidden and exposed) shall be noncombustible or fire retardant. Noncombustible materials shall be determined in accordance with ASTM B 136 (Test for Determining Noncombustibility of Elementary Materials). Materials which are inherently fire retardant or have received a fire retardant treatment shall produce a flame spread rating of not more than 25 when tested in accordance with ASTM E 84 (Surface Burning Characteristics of Building Materials). The fire retardant treatment shall not be subject to degradation due to weathering or custodial operations such as cleaning, washing, etc. Plastic materials (including foam insulation and sandwich panel rigid foam) shall be processed to impart self-extinguishing characteristics to the material when tested in accordance with ASTM D 635 and ASTM D 1692, (Flammability of Rigid Plastics Over 0.127 CM in Thickness and Flammability of Plastic Foams and Sheeting, respectively). Ply wood that is incorporated in the shelter design shall be C-C plugged EXT-DFPA grade or better. Bolts, nuts, washers, screws and other metal connectors shall be made of material that will not rust or corrode for the life of the building. Steel skids or framework under the shelter shall be hot-dipped galvanized after fabrication in accordance with ASTM Designation A123 for structural steel and A153 for hardware.

The materials selected shall have been proven as suitable for the intended service life of the structure, service conditions to which it will be exposed, transportation stresses that are expected, and the minimum maintenance that is required. Special provisions shall be taken for the prevention of corrosion and avoidance of unprotected faying surfaces, moisture traps, and galvanic couples due to dissimilar metals.

3.4.10.10 Heat transmission.- The maximum heat transmission coefficient value throughout the roof, walls, floor, and door shall for the localizer and glide slope shelters only be 0.15 Btu/hr./sq. ft./°F. Calculations of the actual heat transmission coefficient shall be submitted for the approval of the Contracting Officer. The calculations shall be in accordance with the methods and values shown in the latest issue of the Heating, Ventilating, and Air Conditioning Guide and Data Book (ASHRAE Guide). There is no heat transmission value for marker shelters as the intent for this building is to provide shelter from inclement weather only.

3.4.10.11 Lockset.- The exterior door shall be provided with a cylindrical, lockset equal to Model 7K7E6-US10 manufactured by Best Lock Co., Inc., Indianapolis, Indiana. The lockset shall be one which is adaptable to the existing FAA key locking system provided by Best Lock Co. The lock shall be provided with a construction core which will be replaced by the Government with a regular FAA core.

3.4.10.12 Floor.- The floor for the shelters shall be covered with 1/8" light green vinyl-asbestos tile conforming to Federal Specification SS-T-312. The floor adhesives shall resist degradation from exposure to solvents and oil.

3.4.10.13 Roof.- There shall be no roof mounted equipment on the localizer and glide slope shelters. The roof shall sustain a 200 pound live load, concentrated on one square foot placed at the center of the roof simultaneously with a 40 p.s.f. snow road with a maximum deflection of 1/360 of the spans. The roof shall be designed to withstand 40 p.s.f. uniform snow loading without damage.

3.4.10.14 Openings.- All openings for conduit, duct work, etc., shall be provided in the shelters as necessary for field installation of the system. Weatherproof covers shall be provided for each opening and provision shall be made to maintain the insulation rating of the shelter if the opening is not in use. A weatherproof closure shall be provided to seal around each conduit, or cable that passes through an opening in the shelter. Hoods (with filter holders for intake air) and insect screens shall be provided for all air intake and exhaust openings. Hoods shall be detachable for transportation. Hoods shall be galvanized steel (minimum 24 guage) or other materials with equal strength and corrosion resistance properties.

3.4.10.15 Doors.- The shelters shall have one exterior door. The door shall be a minimum of 3'-0" wide and a minimum of 7'-2" high. The door shall be structurally sound, impervious to the weather and shall be insulated in the localizer and glide slope shelters. A minimum of three (3) hinges of the "non-rising" pin type, are required on each door. The door shall open out and be equipped with a brass or bronze threshold and weather stripping to prevent dust and moisture entry. A rain hood shall be provided for installation over the door opening. The hood shall be detachable during periods of transportation.

3.4.10.16 Transportation.-The contractor shall design a method of transportation and handling for the shelters. The requirements of the specific techniques shall be provided on the shelter structure for the attachment or positioning of sling cables to facilitate lifting (loaded with electronic, electrical and mechanical equipment) to and from transport vehicles and onto the foundation. Lift points shall be permanently identified on the outside walls with 1/2" high letters or weld metal beads or letters recessed into a metal plate. Over-the-road transportation may be on either a flat-bed trailer, low-bed trailer, or other means which meet ICC regulations for interstate transport in all states in the continental Unites States. The floor structure of the shelters shall be designed for loading onto an 8'-0" wide trailer without special support or pallets.

3.4.10.17 Foundation design.- The shelters shall be designed for installation on a concrete slab, piers, or grade beam at a minimum of 6" above the finished site grade. Hardware required for tie down of the shelter, except anchor bolts inbedded in the foundation, shall be furnished. The contractor shall design and prepare standard foundation construction drawings and specification suitable for Government contracts with small general contractors at field installation sites. An allowable soil bearing pressure of 3,000 pounds per square foot shall be assumed for the design, with a 48" maximum frost penetration. Additional data shall be provided to permit site adaptation by the Government when soil conditions are less than standard.

3.4.10.18 Steps.- Metal steps with an integral safety handrail and a 4 foot deep by 4 1/2 foot wide minimum size top landing shall be provided at each door for personnel access to the shelter. The steps shall be removable for transportation and shall be designed for anchoring to a poured concrete pad (not provided as a part of this specification) in accordance with instructions to be furnished by the contractor.

3.4.10.19 Air conditioning.- The contractor shall select and furnish a window type air conditioner for the localizer and glide slope shelters only. Equipment and installation shall be in

accordance with FAA-C-2256. The system shall be sized to maintain the conditioned space at 75°F dry bulb and less than 50% relative humidity with normal design conditions at 100°F dry bulb and 76°F wet bulb, with not less than 20 percent spare capacity of the design load. The air conditioning load shall be calculated in accordance with the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Guide and Date Book and based on the internal heat loads of the electronic equipment in the normal mode of operation as well as any mechanical heat loads that might be within the conditioned space. Use the shelter orientation which yields largest solar heat design conditions. Included in the air conditioning load shall be all lighting fixtures illuminated, one occupant, and transmission gains through roof, wall, and floor areas including solar load.

3.4.10.20 Air filters.- All outside air entering the shelters shall be filtered with throw-away type filters, not less than 1" thick. Filter face velocity shall not exceed 300 f.p.m.

3.4.10.21 Heating.- The contractor shall provide thermostat controlled electric heating to maintain an inside temperature of 75°F in the localizer and glide slope shelters with an outside temperature of 0°F. Credit shall not be taken for heat from the electronic equipment.

3.4.10.22 Ventilation.- The contractor shall provide thermostatically controlled ventilation equipment in the localizer, glide slope and marker shelters of sufficient capacity to limit the inside space temperature to not more than 10°F rise above the outside ambient temperature. Propeller fans, if provided, shall conform to MIL-F-16081, direct drive, wall mounting type equipped with gravity shutters. Relief air dampers shall be motor operated. Intake and exhaust openings shall have weather hoods and shall be equipped with insect screens.

3.4.10.23 Controls.- Air conditioning, heating, and ventilation controls in the localizer and glide slope shelters shall be interlocked to prevent simultaneous operation, however, an override switch shall be provided for the ventilation system. Air conditioners shall have adjustable start relays. The ventilation shall automatically start operation when the inside space temperature exceeds 95°F in the shelters, but the thermostat shall have a minimum adjustment range from 55° to 95°F. The ventilation thermostat in the marker beacon shelter shall have a minimum adjustment range of 55° to 95°F. The thermostat(s) shall be located in a position not subject to drafts or extreme temperatures and not less than four feet above the finished floor. All controls, thermostats, and indicators shall have permanent markings to indicate system and function.

3.4.10.24 Electrical, General.- Electrical equipment shall be designed, sized, arranged, and furnished to accommodate all of the electrical power requirements of a complete ILS facility, including the antenna system and optional equipment. The design shall be in accordance with the National Electrical Code and Specification FAA-C-1217. In the event of conflict, Specification FAA-C-1217 shall govern. Marking shall be in accordance with FAA-C-1217.

3.4.10.25 Distribution system.- The Government will provide 120/240V, 60 Hz, single phase, three wire, underground commercial power service to the localizer, glide slope and marker facilities. The shelter electrical distribution system shall commence with the incoming service conduit and conductors as they enter the shelter floor or wall and extend throughout the facility, including the antenna system and support tower. Spare electrical capacity of not less than 20% of the design load shall be provided in the distribution panelboard capacity and distribution wiring. Short circuits and overloads shall be cleared at the lowest possible level in the system via proper coordination of circuit breakers or fuses or both.

3.4.10.26 Panelboard and circuit breakers.- A 120/240 volt, single phase, 3 wire distribution panelboard with a main breaker and the required number of properly sized circuit breakers shall be provided to furnish power via individual circuits to the electronic equipment, antenna heaters where required, electrical/mechanical equipment, lighting, tower obstruction lights (in accordance with Advisory Circular AC 70/7460-1), battery charger, and miscellaneous equipment. One 15 ampere single pole and one 20 ampere two pole spare circuit breakers shall be provided for each distribution panelboard. One (1) ground fault interrupting device shall be furnished and installed to be used for convenience outlets to be installed outdoors. Surge protectors Joslyn # 1235-01 or equal shall be connected to the incoming service on the line side of the main distribution panelboard to limit surge voltages and prevent harmful transients from entering the system that could cause damage to the electrical or electronic equipment.

3.4.10.27 Wiring.- Wiring shall be provided in accordance with the National Electrical Code and FAA-C-1217. All wiring shall be run in duct or conduit. Wiring diagrams and graphic symbols shall be in accordance with FAA-STD-002. All power wiring shall be color coded in accordance with the National Electrical Code from its origin at a panelboard circuit breaker to its termination inside electronic equipment cabinets, mechanical/electrical equipment, or outlets.

3.4.10.28 Outlets.- A 120V single phase 20 ampere duplex outlet shall be provided above each work bench. In the localizer and glide slope shelters, a 240V grounded type, single outlet receptacle shall be installed 2'-0" above the floor on the opposite wall from the primary heating unit. The outlet will be for the future addition of a supplementary heater by the FAA. The outlet circuit shall be served by a 20 ampere breaker in the power disbribution panel and the outlet shall be labeled "240V heater" in 1/2" high black letters on the wall below the outlet. In the marker shelter, a 120V single phase outlet shall be installed 2'-0" above the floor. This outlet will be for the future addition of a supplementary heater by the FAA. The outlet circuit shall be served by a 20 ampere breaker in the power distribution panel and the outlet shall be labeled "120V heater" in 1/2" high black letters on the wall below outlet.

3.4.10.29 Lighting.- Lighting levels and equipment shall be designed in accordance with the tasks to be performed, the Illuminating Engineering Society Handbook and National Electrical Code criteria and requirements. The minimum level of Interior Illumination shall be 75 foot candles at a horizontal work plane 30" above the floor. Exterior illumination, minimum 60 watts incandescent lamp in weatherproof fixtures, shall be provided at the door for personnel safety. The light fixtures shall be controlled by the interior wall mounted switches located on the latch side of the entrance door. Interior lighting fixtures except for the marker beacon shelter shall be flourescent type. A portable reel type light, equal to Appleton Reelites, Catalog No. RE-752G Grounded, shall be provided in the vicinity of the equipment areas in the localizer and glide slope shelters only.

3.4.10.30 Grounding protection.- The shelters shall utilize two separate and distinct grounding subsystems, one for electronic equipment cabinets and one for the electrical power system. The contractor shall connect each grounding subsystem together at a common point for ultimate attachment to site earth ground. Metal shelter structural members and siding, and conduits/ducts shall be electrically continuous and grounded in accordance with the National Electrical Code. Where enamel finished ducts and wireways are used, each straight section, ell, tee, and collar (where the collar enters junction boxes, panelboards, etc.) shall be electrically grounded with a #6 bare copper wire through special clamp designed therefore.

3.4.10.31 Ductwork, conduit, and cable.- Ducts and conduits shall be sized, arranged, and located to accommodate power conductors, and all coaxial and control cable required to provide a complete and usable system. Electronic ductwork shall be located for optimum interconnection capability between equipment cabinets. Ductwork shall be wall or ceiling mounted for maximum accessibility. The duct system shall facilitate expansion to install future equipment.

3.4.10.32 Data plate.- A nonferrous metal data plate, approximately 3 inches by 6 inches, shall be provided on the lower exterior surface at the lock side of the exterior door of each shelter so as not to be hidden by steps or foundation work. The data plate shall contain the following information in the order listed:

SHELTER, LOCALIZER/GLIDE SLOPE OR MARKER, TRANSPORTABLE

Manufactured by (manufacturer's name) for

FEDERAL AVIATION ADMINISTRATION

FAA Type number:_____
Contract number:_____
Serial number:_____
Curb weight:_____
Gross weight, maximum:_____pounds
Shelter Subcontractor:_____
Shelter Subcontractor: (if applicable)

Maximum gross weight is defined as the maximum possible weight of the shelter and its contents as described in paragraph 3.4.10.4. Curb weight is defined as the shelter weight with only mechanical and electrical equipment installed. The manufacturer's name shall not be visible on the finished shelter except on the data plate.

3.4.10.33 Documentation delivery.- The originals of the construction drawings and specifications, reproducible copies of the standard layouts, shelter fabrication drawings and specifications, and final copies of related design calculations shall be delivered to the Contracting Officer or set forth in the contract schedule. The original submissions for review and approval shall be delivered as set forth in the contract delivery schedule. The originals of the standard layouts and shelter fabrication drawings and specifications with all modifications, corrections, and as-built changes shown shall be delivered to the Contracting Officer as set forth in the contract schedule.

3.4.11 Health and safety.- Dependable protection of operational personnel against health and safety hazards and against damage to equipment through malfunctioning of any equipment that comprises the Category III ILS shall be provided as an integral feature of the system design. This design shall satisfy the applicable requirements described in the U.S. Department of Labor, OSHA, Occupational Safety and Health Standards as required by the Occupational Safety and Health Act of 1970. Adequate provisions shall also be included for ensuring the health and safety, of personnel from the hazards of moving machinery, high voltages, high intensity RF radiation, and X-Ray. Necessary indicators and alarms shall be provided to indicate the status of working or faulty conditions of equipment. All protection, safety and devices shall, as far as possible, be on the fail-safe principle.

As a minimum, the following provisions shall be made for the health and safety of operating personnel:

(a) Safety shields shall be provided over all moving parts in which personnel could become entangled or caught;

(b) The outside of all cabinets, racks, and chassis of all equipments, frames of all motors and generators, all external metal parts, meter cases, control shafts and adjusting devices must be grounded. All components in metal cases such as transformers, reactors, capacitors, etc., shall have their cases grounded;

(c) All terminal strips containing hazardous voltages (100 volts or over), including powerline voltages, shall be equipped with barriers between terminals and a removable cover of insulating material. The design of the cover and barriers shall be of sufficient mechanical rigidity to prevent inadvertent contact and short circuits;

(d) Where voltages in excess of 300 volts peak AC or 300 volts DC are employed, at least one prominent cautioning notice in red shall be provided on the cover of each unit involved;

(e) Grounding devices shall be provided in all areas of the equipment in which voltages in excess of 300 volts exist. The devices shall be permanently grounded through and to the equipment rack or cabinet, and storage clips shall be provided;

(f) Equipment in which access to voltages in excess of 300 volts AC or DC obtained by opening doors, by removing a panel or by sliding out a chassis, shall be de-energized by interlocks. Circuits in excess of 600 volts shall be grounded by an automatically operated "deadman" grounding device:

(g) Means shall be provided so that maintenance personnel can temporarily disable an interlock for the purpose of making tests. When the door, panel or drawer is returned to a closed condition, normal interlock operation shall be automatically restored. When such disabling is done, a suitable warning light shall be lighted.

(h) Cables shall have energized conductors appearing only on female connectors;

(i) The segregation of power cable from cables carrying communications and control signals is required; and

(j) Cabinets and enclosures shall be designed to protect personnel from radiation hazards. With all panels, doors and other shielding in place, the RF radiation flux density shall not exceed 10 mw per square centimeter at a distance of one foot from the cabinet. X-ray radiation shall not exceed 2 milliroentgen per hour. Shall these values be exceeded with the covers removed, appropriate warning of radiation hazard shall be placed on the equipment. If a tuning or maintenance operation is necessary with covers removed and equipment energized, the above specifications shall be met with cover removed.

3.4.12 Drawing requirements.-All relevant drawings shall be provided that identify the Category III ILS and are required to describe the system, subsystems, and equipment units for the purpose of installation. Drawings for the localizer, glide slope and markers shall be prepared and furnished by the contractor, complete, in accordance with all requirements, and shall include the items tabulated below. Each subsystem shall perform as specified when installed in accordance with the data furnished. Submission times are as shown in the contract schedule.

(a) Standard layouts - for the localizer, the glide slope and marker shelters, all equipment and site layout.

(b) Design/fabrication drawings and specification - Including construction of the transportable shelters and installation of all electrical, and mechanical and electronic systems.

(c) Construction drawings and specification - including foundations; grounding and underground connections and interface with the antenna.

(d) Calculations - including all design calculations, environmental control equipment capacity, calculation, design assumptions, and parameters.

(e) Connection and tabular wiring diagrams showing the interconnection between various equipment units of each subsystem, including details, such as color codes of all wiring, and connectors required for the installation.

(f) Installation and mounting details including physical dimensions for equipment units and interfaces with outside units and the mounting hardware for equipment units.

(g) All drawings shall be made on clear-print No. 1000 H or equal with the FAA title block in the lower right hand corner. Provide 1/2" border lines on the top, bottom, and right hand side. Provide 1 1/2" border on the left side. The drawings shall be made on "D" size sheets (22" x 34"). Sample title and index sheets will be furnished.

(h) Drawings will be prepared in accordance with FAA-STD-002. These drawings will be reduced in size by the FAA in the future. For this reason, the contractor shall assure that all drawings are clear and legible. The details and printing shall be of the size required for microfilming on 35 mm film. The minimum letter height for a 22" x 34" sheet will be 5/32" and .05" spacing between letters. All letters shall be vertical capital letters.

3.4.12.1 Design submission and approval.- The contractor shall furnish the Contracting Officer or his designated Technical Representative three copies of the standard layouts, the design/fabrication drawings and specifications, and the construction drawings and specifications for review and approval. Also three copies of calculations necessary to support all design requirements contained herein. No fabrication work shall be started until all design documentation has been approved by the Government. Design approvals shall in no way relieve the contractor from meeting the requirements of this specification.

3.4.13 Instruction books.- Manuscript Copies of the instruction books in accordance with the requirements of Specification FAA-D-2494/1 and FAA-E-2494/2 shall be furnished as specified in the invitation for bids or request for proposals and as further specified herein. Individual instruction books shall be provided for the localizer station, glide slope station, marker beacon stations, far field monitor, remote indicating and control unit, and maintenance monitor (if furnished). The instruction books shall also include the description, maintenance, operation of the structural, mechanical and electrical systems furnished.

3.5 VHF Localizer subsystem

3.5.1 Localizer general requirements.- A completely equipped VHF Localizer subsystem shall consist of the following.

(a) Dual transmitters with associated modulation, control, and automatic change over equipment.

(b) Localizer antenna array(s) with associated cabling, divider network(s), or distribution unit(s), integral monitoring pickup devices and combining unit(s), obstruction lights, antenna support structures.

(c) One Localizer Monitor group.

(d) One shelter group, complete with electrical wiring and environmental controls, as specified in 3.4.10.

3.5.2 Localizer operational requirements.- The VHF Localizer shall provide lateral guidance in the horizontal plane to aircraft in approaches to and landing at airfields. The radiation field pattern shall produce a composite field pattern which is amplitude modulated by a 90 Hz and a 150 Hz tone.

The radiation field pattern shall be such that when air observer faces the Localizer from the approach end of the runway, the depth of modulation of the radio frequency carrier due to the 150 Hz tone shall predominate on his right-hand side and the 90 Hz tone shall predominate on his left-hand side.

3.5.2.1 Operational radio frequencies.- The VHF Localizer subsystem shall be inherently capable of operating on any carrier frequency, in 0.05 MHz increments, within the operational band of 108 to 112 MHz without basic design changes. The frequency tolerance shall not exceed $\pm$ 0.002 percent.

The VHF Localizer subsystem, as provided, shall operate on one of the selected operational carriers as listed in Table 1, Localizer Operational Frequencies. The operational frequency shall be specified by the Government. The operation of the VHF Localizer subsystem at the different frequencies as listed in Table 1 may require substitution of modular devices. To change the operational carrier frequency, the VHF Localizer subsystem shall be capable of being modified by modular substitution only. Only adjustments which are considered to be of field level nature shall be required for a frequency change. If a two-frequency configuration (capture-effect) is employed, the frequencies of the RF carriers shall be individually adjustable and the nominal band occupied by the carriers shall be symmetrical about the assigned frequency. The frequency separation between the course and clearance carriers with all tolerances applied over the environmental conditions shall not be less than 5 KHz nor more than 14 KHz.

TABLE 1. LOCALIZER OPERATIONAL FREQUENCIES
(MHz)

108.1	109.1	110.1	111.1
108.15	109.15	110.15	111.15
108.3	109.3	110.3	111.3

108.35	109.35	110.35	111.35
108.5	109.5	110.5	111.5
108.55	109.55	110.55	111.55
108.7	109.7	110.7	111.7
108.75	109.75	110.75	111.75
108.9	109.9	110.9	111.9
108.95	109.95	110.95	111.95

3.5.2.2 Coverage.- When the transmitter RF power output is reduced to the monitor alarm point, the Localizer shall provide signals along the front course line sufficient to allow satisfactory operation of a typical aircraft installation within the Localizer and glide slope coverage sector. Each sector is nominally ± 10 degrees at a distance of 25 nautical miles and from ± 10 to ± 35 degrees at a distance of 18 nautical miles from the center of the localizer antenna. Signals shall be receivable, over the specified coverage, at and above a height of 1500 feet above the elevation of the threshold reference or 1000 feet above the elevation of the highest point within the intermediate and final approach area, whichever is the highest, up to a surface extending outward from the Localizer antenna and inclined at an angle of 7 degrees above the horizontal. The ratio of course-signal to clearance-signal strength in space within the front course sector to the coverage limit shall be not less than 10 dB where coverage is achieved by a Localizer subsystem utilizing two radio frequency carriers. The requirements of Annex 10, Part I paragraph 3.1.3.3.2.3 are also applicable.

3.5.2.3 Polarization.- Localizer radiation shall be horizontally polarized. The vertically polarized component within a sector bounded by 0.02 DDM on either side of the course line shall not exceed that which corresponds to a DDM error of 0.005 when an aircraft is in a roll altitude of 20 degrees from the horizontal.

3.5.2.4 Modulation.- The nominal depth of modulation of the radio frequency carrier due to each of the 90 Hz and 150 Hz tone shall be 20 percent and the modulation shall be within 19-21 percent.

3.5.2.5 Course alignment accuracy.- Based on a nominal sector width of 700 feet at threshold, the mean course line shall be adjusted and maintained within limits equivalent to ± 10 feet from the runway centerline at the ILS reference datum.

3.5.2.6 Displacement sensitivity.- The nominal displacement sensitivity within the half course sector at the ILS reference datum shall be 0.00044 DDM/foot, based on a nominal sector width of 700 feet at the ILS reference datum. The increase of DDM shall be substantially linear with respect to angular displacement from the front course line (where DDM is zero) up to an angle on either side of the front course line where the DDM is 0.180. From that angle to ± 35 degrees, the DDM shall be not less than 0.180. When the course is widened sufficiently to cause an alarm, the DDM shall be not less than 0.165 from ± 4 to ± 10 degrees.

3.5.2.7 Course sector width.- The Localizer sector width shall be tailored to a value of 700 feet at the runway threshold, except that is shall be not less than 3.0, nor more than 6.0 degrees and shall be maintained within 10 percent of the tailored value. The sector width shall be easily adjustable between the values of 2.4 and 7.2 degrees.

3.5.2.8 Identification.- The Localizer shall provide for the simultaneous transmission of an identification signal on the same radio frequency carrier as used for the Localizer function. The transmission of the identification signal shall not interfere in any way with the basic Localizer function. The identification signal shall be produced by Class A2 modulation of the radio frequency carrier using a modulation tone of 1020 ± 50 Hz. The emissions carrying the identification signal shall be horizontally polarized. Where two carriers are modulated with identification signals, the relative phase of the modulations shall be such as to avoid the occurrence of nulls within the coverage of the Localizer. The identification signal shall employ the International Morse Code and shall normally consist of three letters. It shall be capable of being preceded by the International Morse Code signal of the letter "I". The identification signal shall be transmitted at a speed corresponding to approximately 7 words per minute, and shall be repeated at approximately equal intervals, not less than 6 times per minute, at all times during which the Localizer is available for operation use. During all times that the Localizer is not available for operational use, as for example during removal of navigational components or during test or maintenance, the identification signal shall be suppressed. The identification modulation of the carrier shall be adjustible to all percentages from zero to 15 percent. A continuously adjustable control shall be provided for this purpose.

3.5.2.9 Localizer site criteria.- The Localizer antenna equipment group shall be designed to be located at the stop end of the runway and to be positioned on the runway centerline extended in a symmetrical orientation. Other siting considerations are as follows:

(a) Minimum distance.- The minimum distance from the stop end of the runway to the Localizer antenna shall be not less than 600 feet. The optimum distance is 1000 feet.

(b) Maximum distance.- The maximum allowable distance from the stop end of the runway to the Localizer antenna shall be 2000 feet.

(c) Elevation of the Localizer antenna.- The antenna shall have the minimum height necessary to satisfy the coverage requirements specified in 3.5.2.2. The placement of the antenna shall be consistent with safe obstruction clearance practices.

3.5.3 Localizer transmitter group

3.5.3.1 Localizer transmitter group, general requirements.- The VHF transmitter group shall be composed of those equipments involved in the generation, regulation, and modulation of localizer signals by dual systems, interchangeable in main or "hot" standby configuration. While the designated main system is operating into the antenna group, the designated standby system shall be operating under monitor system control into a dummy load through a changeover-test assembly. Immediate changeover shall be effected automatically on command of the monitoring system or by manual override.

3.5.3.2 Localizer transmitter group performance.- The transmitter units shall be crystal oscillator controlled and shall be capable of operation on all assigned Localizer frequencies within the range of 108 MHz to 112 MHz with continuously adjustable output power, rejection of harmonic frequencies and noise, and modulation characteristics as specified under this paragraph. The transmitter type shall be capable of serving either course or clearance signal generated functions. Both course and clearance (capture effect configuration) transmitters shall perform as follows over the service conditions indicated in paragraphs 3.5.3.3 through 3.5.3.5.

3.5.3.3 Transmitter output power.- The transmitter carrier output power over the frequency range shall be adjustable from 10% to 150% of that required to meet the coverage specified. Adjustment of at least 40 percent of 100 percent of the rated transmitter output power over this range shall not change the modulation balance by more than 0.002 DDM, the course width by more than 2.0

percent and the percentage of identification modulation by more than 10 percent of normal. Power output shall not vary more than ± 5% with DC operating voltage variations of ± 15%.

3.5.3.4 Transmitter stability.- After initial adjustment under normal test conditions for optimum transmitter conditions, changes over the service conditions shall not exceed the limits tabulated below:

(a)	Carrier power at carrier output	± 10 percent
(b)	Sideband ratio	± 0.5 dB
(c)	Carrier modulation	± 1 percent (each tone)
(d)	Carrier modulation balance	± 0.005 DDM
(e)	Sideband balance	± 0.3 dB
(f)	RF phase between carrier and sideband outputs	± 10 degrees
(g)	Navigational tone frequency	± 1.0 percent
(h)	Transmitter frequency	± .0002 percent
(i)	Harmonics or noise signal	60 db below carrier output level
(j)	Residual carrier modulation	0.1%
(k)	Identification frequency	± 15 Hz

3.5.3.5 Stabilization time.- After initial adjustment under normal test conditions, changes from the initial room temperature readings occurring between three second and 15 minutes after initial application G-2100/1 (modifies 1-4.12 for this application) shall not exceed the limits tabulated below. The readings for each parameter shall be taken at three seconds after energization, and on a continuous recording basis for 15 minutes after energization.

(a)	Carrier power at carrier output	± 10 percent
(b)	Sideband ratio	± 0.5 dB
(c)	Carrier modulation	± 1.0 percent (each tone)
(d)	Carrier modulation balance	± 0.005 DDM
(e)	Sideband balance	± 0.3 dB

(f)	RF Phase between carrier and sideband output	± 10 degrees
(g)	Navigation tone frequency	± 1 percent
(h)	Identification frequency	± 15 Hz
(i)	Transmitter frequency	± .0002 percent

3.5.3.6 Control functions.- A switch shall be provided to turn the transmitter output radiation on and off. In addition, it shall be possible to select either local or remote control of this function.

3.5.3.7 Crystal.- Two of each channel determining crystals shall be furnished with each transmitter in accordance with a listing of channel frequency assignments which will be furnished by the Government. In order to change the transmitter frequency, the cyrstal shall be the only component requiring replacement. The crystal shall be easily removable from a plug-in socket.

3.5.3.8 Crystal Oscillator Stability.- Crystal oscillators and and related components shall be selected to ensure output frequency stability within ± 2 ppm over environmental II Service conditions and DC supply voltage variations of ± 15%.

3.5.3.9 Crystal oven.- A crystal oven shall not be used.

3.5.3.10 Resonance points.- There shall be no indication of more than one resonance point over the complete range of travel adjustment for all controls normally used in tuning or adjusting the transmitter to meet equipment specification requirements. This requirement shall be met over the specified frequency range either during the procedure of tuning the transmitter or after all stages are tuned to resonance, regardless of the transmitter power output.

3.5.3.11 Indicator lights.- Indicator lights shall be provided and mounted on the front panel of the RF unit to indicate the application of power and local-remote control.

3.5.3.12 Identification modulation.- Identification tone signal modulation of the transmitter(s) shall be adjustable between 0 percent and 15 percent and shall modulate the maximum carrier output 10 percent with no more the 8.0 percent modulation distortion.

3.5.3.13 Identification unit.- The identification unit shall be a solid-state oscillator/keyer capable of the generation of 1020 Hz morse code characters as required for Localizer station identification. Character generation shall be digitally controlled and shall be programmable by the use of strapping jumpers or equivalent. The keyer shall provide character timing as follows:

(a)	Dot length:	0.125 second
(b)	Dash length:	0.375 second
(c)	Length of space between dots and dashes in a continuous series and within a code character	0.125 second

3.5.3.14 I.D. unit performance.- The keying rates shall remain within ± 15 percent of the design center values under the environment service conditions of temperature and humidity. Keying pulses shall start without undesirable transients, shall have not discontinuities, and shall stop without undesirable transients. Transient peaks due to keying shall not exceed 2 percent of the peak amplitude of the normal audio frequency waveform at the modulator output. It shall be possible to select either keyed or unkeyed modulation or to remove all modulation from the transmitter. Additional keying performance and other requirements are as follows:

(a) Tone oscillator frequency shall be 1020 Hz, ± 15 Hz over Environment II Service conditions and nominal DC Supply voltage variation of ± 15%.

(b) Distortion shall not exceed 2 percent at + 5 dBm.

(c) Output stability shall be ± 1 db over Environment II Service conditions and nominal DC Supply voltage variation of ± 15%.

(d) Character output capability shall be the Morse Code letter "I" plus two or three selectable Morse Code Identification letters.

(e) DME keying output.- Provisions shall be provided for synchronous keying of an associated DME facility (not furnished under this specification). When DME identification is desired, every fourth cycle of localizer transmission identification keying shall be omitted and presented instead in the form of continuity keying of the DME output terminals. Thus the DME will be keyed with one cycle of

Morse Code identification approximately every 30 seconds, followed by three (3) localizer keying cycles. Keying of the DME is accomplished by completing the positive ground return of a 48 VDC relay. The relay and operating voltage are not required to be furnished under this specification. One output terminal is permitted to be at equipment ground potential. The maximum open circuit voltage appearing on the other terminal will be 50 VDC. The relay current will not exceed 25 ma, under which conditions the voltage drop across the terminals shall not exceed 1.0 volt. DME keying shall not be affected by operation of the Localizer keyer selector switch described under the Identification Unit portion of this paragraph.

3.5.3.15 VHF Modulator.-The modulator assembly shall be capable of generation and synchronization of 90 Hz and 150 Hz sine wave tones, and the amplitude modulation of the radio frequency carrier with these tones.

3.5.3.16 Modulator assembly design.- The modulator assembly shall provide: (1) an output containing the RF carrier modulated by the navigation tones and identification tone, (2) an output containing only the separate sideband frequencies of the navigation tones. Mechanical modulation techniques shall not be employed in the design of the modulator. Input/output impedance shall be 50 ohms nominal and the input vswr shall not exceed 1.15:1.

3.5.3.17 Modulation tones.- The modulating tones shall be 90 Hz and 150 Hz within $\pm$ 1.0 percent.

3.5.3.18 Audio phase of modulation tones.- The modulating tones shall be phaselocked such that the demodulated 90 and 150 Hz signals appearing at the carrier output pass through zero within 50 microseconds of each other in the same direction, every 1/30 second.

3.5.3.19 Carrier modulation.- Modulation of the carrier output signals over a minimum range of 17 to 23 percent for each navigational tone, shall be accomplished by the use of a continuously adjustable control which shall not produce a change of more than $\pm$ 5 degrees in RF phase between carrier sideband outputs as measured over the service conditions of temperature and humidity. Adjustment of the modulation control over the range specified herein shall have no effect on course structure, or symmetry of course width.

3.5.3.20 Modulation balance adjustment.- A continuously adjustable control shall be provided for precisely adjusting the total modulation balance, and for simulating changes in the localizer course position. Throughout the range of adjustment of the modulation percent control, and without making any other adjustment within the modulator, adjustment of the modulation balance control shall provide total modulation balance. The control shall enable the localizer to be adjusted to meet the course alignment requirements.

3.5.3.21 Sideband amplitude control.- A sideband amplitude control shall be provided to enable adjustment of the localizer course sector width over the range of 2.0° to 7.5°. Adjustment of this control over its range shall not change the carrier to sideband phasing by more than ± 5.0 degrees as measured over the service conditions of temperature and humidity.

3.5.3.22 RF phaser control.- A continuously adjustable phasing control shall be provided for shifting the RF phase of the signals appearing at the carrier output over a range of at least ± 30 degrees from normal.

3.5.3.23 Modulator navigation tone control.- A control shall be provided to enable independent removal of the navigation tones from the RF carrier.

3.5.3.24 Modulator test circuits.- For test purposes, a minimum of four identical linear detectors for sampling the respective signals at the carrier output, sideband output, 90 Hz and 150 Hz output, shall be provided. The output of each of the linear detectors shall be a minimum of 300 millivolts into a 20K ohm load and shall be available at type BNC coaxial connector test jacks.

3.5.3.25 Carrier signal at sideband output.- With the modulator adjusted for optimum conditions, for any combination of sideband amplitude control or sideband phaser control settings, the carrier power appearing at the sideband output shall be 60 dB or more below the carrier power appearing at the carrier output when measured over the service conditions of temperature and humidity.

3.5.3.26 Distortion of demodulated navigation tones.- With the equipment adjusted for optimum conditions, the signals appearing at the Carrier Output and Sideband Output test jacks shall be such as to produce a demodulated signal with equal 90 and 150 Hz components and distortion components which do not exceed the following.

Frequency	Distortion component referred to 90 or 150 Hz signal
180 Hz	3 percent
270 Hz	4 percent
300 Hz	4 percent
450 Hz	4 percent
All other frequencies within the range of 30 to 4000 Hz	2 percent

In addition, the total harmonic distortion shall not exceed 8 percent. The above distortion requirements shall also be met when the input power to the modulator is varied over the specified range of the transmitter power output.

3.5.3.27 Equipment changeover, test, and energy distribution requirements.- Changeover circuits shall be used to connect the antenna to the principal or standby transmitter channel on command of the control unit. Four thruline wattmeter detectors shall permit testing of waveform and power levels of the signals for maintenance and alignment purposes, while phase and power corrected outputs from the designated standby transmitter/ modulator are continuously monitored for operational readiness. Changeover and test performance shall be as follows:

(a) Impedance shall be a nominal 50 ohms at all RF ports.

(b) Insertion loss shall not exceed 0.4 dB.

(c) Switching time to changeover the standby transmitter to the antenna array shall not exceed 300 milliseconds (ms) after command of monitor control.

(d) VSWR of the RF ports shall not exceed 1.15:1.

(e) Phase error due to internal line lengths shall not exceed $\pm$ 2 degrees.

(f) Any RF signal from the standby subsystem shall be at least 60 dB below the carrier level of the main unit as measured at the input to the antenna equipment group.

3.5.3.28 Phase shifter requirements.- Continuously adjustable phase shifters shall be provided for shifting the RF phase of the signals appearing at the sideband output for the main and standby equipments in both course and clearance transmitters. Phase-shifter minimum performance shall be as follows:

(a) Nominal impedance shall be 50 ohms with VSWR not exceeding 1.15:1.

(b) Minimum net phase angle adjustment capability shall be plus and minus 30 degrees at 110 MHz.

3.5.4 Localizer monitoring and control

3.5.4.1 Monitoring general requirements.- The localizer station subsystem shall be equipped with a high integrity monitor group for fault detection. Automatic switchover or shutdown shall be initiated on command of the monitor group when critical parameters exceed specified limits. The monitor group shall be capable of operation in conjunction with a remote indicator/control unit, providing audible (including Localizer ident) and visual indication of subsystem status and complete, positive control over the subsystem. The Localizer subsystem shall have triple monitors such that each specified radiated parameter (course, width, clearance) is examined by three identical monitor channels, including detectors with inputs in parallel. Two identical monitor channels shall sense a parameter (RF, SDM and/or DDM) as being out-of-tolerance before shutdown or transfer is initiated. The standby transmitter shall be monitored by single monitors for RF, SDM, DDM and Ident out-of-tolerance alarm of a single monitor or loss of the standby transmitter(s) shall produce indications of abnormal operation. The total period of radiation outside the performance limits shall not exceed 1 second. Any of the following conditions shall cause transfer or shutdown, as appropriate.

(a) A shirt of the mean course line from the runway centerline equivalent to more than 10 feet at the ILS reference datum.

(b) Power reduction

(1) Single frequency system. A reduction of power output to less than 50% of normal.

(2) Two frequency system. A reduction of power output for either carrier to less than 80% of normal or to any point causing the guidance signal to fall outside limits for both clearance and course signal.

(c) A change in displacement sensitivity to a value differing by more than 10 percent of nominal.

(d) A change in sum of modulation percentages (SDM) by more than ± 2% of nominal per tone.

(e) Loss of location identification signal or reduction of modulation level to less than 50% of nominal.

(f) When an open or short fault exists at any antenna element, feed or monitor line, RF distribution or recombination circuit.

(g) Mechanical misalignment of any antenna element.

The standby transmitter monitor shall monitor conditions (a) through (e) above for the standby transmitter(s). Monitor channels throughout the Localizer subsystem (except identification tone monitors if separate) shall be functionally and mechanically interchangeable and shall simultaneously monitor the DDM, SDM, and RF level of the detected course and clearance signals. Circuit conditions shall be adjustable within the monitor channel by means of pluggable programming jumpers or switches, and potentiometer settings. A suitable meter or meters, and circuitry shall be provided in the equipment cabinet or in individual channels to allow final calibration of the monitor channel in place, and self test switches or circuitry as required shall provide conditions essential for adjustment. Monitor channel front panel lamps or other devices shall indicate power on and memorized alarms from DDM, SDM, and RF detection logic. Category III and Category II performance level alarm outputs shall be simultaneously generated for DDM alarm levels.

Interface requirements for the individual monitor channel shall include:

(a) DC levels proportional to DDM, SDM and RF levels shall be provided and available to be interfaced for maintenance monitor prealarm generation and/or recorder inputs.

(b) Individual DDM, SDM, and RF level alarms shall be placed on the interface buss as logic levels, and shall be latched until reset from an external control circuit. A general alarm output shall be logic low for all alarms. Front panel lamps or other devices at the individual monitor channels shall indicate the presence of a memorized fault, as well as a power on condition.

3.5.4.2 Localizer monitor fail-safe.- The localizer monitor shall be fail-safe such that failure of any part of the monitor shall either result directly in an alarm condition, or as a minimum, shall not alter any alarm threshold level in the direction of tolerating greater deterioration of the transmitter output characteristics than permitted in the absence of such failures. For such parts as electronic or electromagnetic switching devices where it is not practical to provide fail-safe operation under both modes of failure (open circuit and short circuit), fail-safe protection shall be provided for the mode of failure having the higher probability.

3.5.4.3 Localizer monitor stabilization.- All monitor channels shall be stabilized within 2 seconds after initial application of radiated signals. Concurrently, internal monitor control action shall begin within 2 seconds after initial application of radiated signals when such signals are outside of allowable tolerances. Interaction of all the monitor parameters shall be minimized allowing simple straightforward adjustments of all monitor parameters in turn with minimum readjustment.

3.5.4.4 Far field monitor.- Each of the three monitor channels of the far field monitor shall be capable of simultaneous setting to both Category III and Category II alarm limits. Any two of the three Category III course alarms shall cause the remote control indicator to downgrade the ILS status whenever two Category III monitor alarms exist simultaneously for a period of 0-30 seconds (adjustable at the remote indication and control subsystem). Any two of the three Category II monitor course alarms shall operate to stop all Localizer radiation whenever two Category II alarms exist simultaneously for a nominal period of seventy (70) seconds, unless this function is bypassed at the Localizer subsystem. It shall also be possible to by-pass the localizer FFM functions from the remote control subsystem. The nominal 70-second time delay shall be adjustable between 0 and 120 at the far field monitor seconds and shall be reinitialized automatically each time the DDM, as indicated by both channels, is within allowable limits for a period greater than 50 milliseconds. Five seconds prior to the anticipated shutdown, the monitor shall trigger the Localizer transmitter shutdown alert signal which is a nominal 1900/2100 Hz tone modulation of the transmitter. The output DDM, RF, 90 Hz and 150 Hz audio signals of the channels shall be displayed on a meter at the far field monitor. The far field monitor meter shall have two scales, one with a full scale deflection corresponding to $\pm$ 150 DDM, and the other with a full scale deflection corresponding to $\pm$ .015 DDM. The DDM from each monitor shall be remoted and displayed at the localizer station for use as a maintenance aid.

3.5.4.5 Integral monitor.- Upon detection of radiation faults by at least two identical monitor channels in the integral monitor unit, the control unit shall initiate the following action:

(a) Immediately cease radiation by the principal Localizer transmitter.

(b) Immediately switch to the operating standby unit, if available, or cease radiation entirely if standby unit is not available.

(c) Upon transfer or shutdown, action shall initiate an audible and visual alarm at the remote indication and control unit and a visible alarm at the maintenance facility.

(d) If the fault persists after changeover, the control unit shall automatically cause all Localizer radiation to cease and shall prevent restoration for a period of at least 20 seconds.

3.5.4.6 Identification monitor.- Triplicate monitoring of the transmitted signal and the single monitoring of the standby signal shall be provided with alarm generation based on failure detection by two of the three main monitors or the single standby monitor. Monitor mismatch signal shall be generated based on a one of three detection by the main monitors. Front panel indicators shall identify an alarm. An alarm shall be generated for the following:

(a) Loss of 1020 Hz tone in excess of 17 seconds

(b) Continuous 1020 Hz tone in excess of 17 seconds

(c) Reduction of modulation level by 50%

ID monitor signal inputs shall originate from the monitor system and generate monitor mismatch and general alarms and, as appropriate, shall serve a tone output for audible monitoring at the Localizer subsystem and at the remote indication and control point.

3.5.4.7 Standby monitor action.- Monitor alarms from any monitor of standby transmitter operation shall, after an adjustable delay of from 2 to 5 seconds, cause shutdown of the standby transmitter.

3.5.4.8 Antenna misalignment monitor.- Upon detection of mechanical misalignment of any antenna element which results in an out-of-tolerance condition of the Localizer signal in the far field that is not detected by the integral monitor, the indication and control unit shall cause a facility shutdown.

3.5.4.9 Antenna transmission line open/short monitor.- Upon detection of an open or short in any antenna element, feed or monitor RF line, RF distribution or combining circuit the fault monitor shall cause a facility shutdown.

3.5.4.10 Transmitter environment monitor.- An abnormal environment indicator light shall light at the remote indication and control unit if equipment cabinet temperature is more than 15 degrees C beyond the normal range of temperature maintained by the heater and air conditioner. Environment alarms shall be indicated by equipment cabinet panel lamps and shall be summed in the abnormal indicator at the remote indication and control unit.

3.5.4.11 Transmitter prime power monitor.- An abnormal power indicator light shall light at the remote indication and control unit if power conditions within the subsystem deteriorate such that:

(a) AC primary power fails

(b) Battery/battery charger line voltage falls outside the limits of ± 15 percent.

3.5.4.12 Monitor display requirements.- Provisions shall be made for meter indications and status indicating lights for all parameters monitored. Meters shall be so calibrated that readings may be used directly to ascertain correct values of course alignment and width. Separate status indicating lights shall be furnished for the antenna misalignment detector and open/short fault monitors.

3.5.4.13 Localizer indication and control general requirements.- Monitor outputs shall be maintained to indicate visually the existence of an out-of-tolerance condition, Automatically transfer to the standby transmitter, cause downgrade of facility performance status at the remote indicator unit, or shutdown all radiation, singly or in combination. In addition, any indication given or action taken shall be memorized at the equipment panel. Time delay circuitry, indicator drivers, and power/environment sensors shall be considered part of the indication and control unit.

3.5.4.14 Memorization of monitoring functions.- A means of memorization and non-memorization of the monitor channel DDM, SDM, RF, ID, open/short and antenna misalignment alarms shall be provided by the indication and control unit. A means shall be provided to clear the memorized alarm without affecting facility operation.

3.5.4.15 Transmitter selection control requirements.- The indication and control unit shall provide selection of either transmitter 1 or transmitter 2 as the principal transmitter.

3.5.4.16 Monitor mismatch requirements.- An indication of monitor mismatch shall be energized if a single monitor channel in any integral, or far field monitor alarms. This action shall also light the abnormal conditions warning alarm.

3.5.4.17 Remote indication and control interface requirements.- Interface requirements between the Localizer and the remote indication and control unit shall be provided.

3.5.4.18 Press to test light requirements.- The indication and control unit shall provide a means of testing all lamp bulbs on the monitor channels and on the indicator panel by operation of a momentary switch.

3.5.4.19 Monitor bypass requirements.- The indication and control unit shall have an override switch that disables monitor and control unit action to the remote point during system adjustments.

3.5.4.20 Abnormal warnings.- An abnormal condition indicator at the indication and control unit shall light if any one or more of the following conditions occur:

(a) Subsystem off the air.

(b) Standby transmitter on the air.

(c) Standby transmitter power off.

(d) Monitor mismatch.

(e) Monitor locally bypassed.

(f) Monitor alarm.

(g) Power/environment alarm.

3.5.4.21 Additional indication and control unit provisions.- In addition to the actions previously listed, the indication and control unit shall provide:

(a) On-off status displays for the main and standby transmitters.

(b) A selection between local and remote transmitter on-off controls.

(c) A forced 20 second delay before a manual restart after automatic shutdown of both transmitters.

(d) An off indicating light (in addition to alarm lights) when the subsystem is off the air.

3.5.5 Localizer antenna group

3.5.5.1 Localizer antenna group general requirements.- The antenna group shall consist of low profile (height not exceeding eight (8) feet) directional elements which will radiate course and clearance signals. The antenna group shall be broadband in order to operate throughout the range of 108 to 112 MHz without adjustments. The antenna equipment shall be prefabricated to include radiating elements, radomes (if required) mounting bases and support posts, distribution network, integral monitoring, monitor combining network and detection equipment, misalignment detectors, open/short monitors, interconnecting RF cables, obstruction lights, AC/DC power cables, and duct work. RF and power cable duct work design shall be such that no cables are exposed and that water accumulation in the duct work is prevented.

3.5.5.2 Localizer antenna performance.- The antenna group shall be so designed as to provide a maximum of ± 3 1/2 degrees beamwidth (except for clearance signal) as measured at the half power points, with power reduction of 20 dB or more below course line power for angles exceeding 10 degrees. From ± 40 degrees to ± 170 degrees course radiation shall be at least 26 dB below course line power. The peak value of the carrier radiation shall occur within ± 0.1 degree of a line perpendicular to the center of the array and this line is designed as zero degrees relative azimuth. The peak level of the course producing sideband radiation from the antenna shall occur at angles no greater than ± 5 degrees from zero degrees relative azimuth. Sideband radiation at angles greater than ± 11 degrees shall be at least 20 db below the peak value and at angles greater than ± 15 degrees shall be at least 26 db below the peak value. The front course null shall be at least 30 db below the peak value. For separately generated clearance signals, a minimum of 10 db differential must be obtainable on the glide path between the course and clearance RF signal strengths on the localizer course centerline.

3.5.5.3 Vertical RF pattern.- Vertical directivity shall be designed into each antenna element such that the peak of the major lobe shall occur at an elevation angle not greater than 15 degrees and the beam width of the major lobe shall be not greater than 16 degrees at the half-power points when the antenna is mounted one wavelength above ground. Minor lobes shall be at least 8 dB below the peak of the major lobe when mounted as specified above.

3.5.5.4 Antenna structural requirements.- The antenna structural requirements are specified as follows:

(a) Mechanical design and frangibility.- The antenna element, supporting structure and radome (if provided) shall be as light in weight as possible, consistent with good engineering design, to allow the array to collapse under impact from the wheels of an aircraft with minimum damage to the aircraft. This value of energy is 4,000 inch pounds and shall only be considered in a line parallel with the runway centerline.

(b) Antenna height.- The overall height of the antenna(s) when mounted on the normal antenna support shall not exceed 10 feet above ground level; however, the antenna shall be capable of being mounted on an elevated support structure.

(c) Radomes.- Individual radomes shall be provided for each element of all antenna arrays if required to provide stability under the specified environment service conditions. The radomes, if provided, shall be as small as possible consistent with providing the required freedom from ice and snow effects. Radomes, if utilized, shall be fabricated of Type III glass fibre base plastic material in accordance with L-P-383 (Modifies paragraph 1-3.15.3 of FAA-G-2100/1).

3.5.5.5 RF distribution unit.- Each array shall be furnished with the appropriate RF distribution unit to provide the proper current excitation to meet the specified array patterns. The design characteristic impedance of the distribution unit RF input and output ports shall be nominal 50 ohms with all other parts terminated into 50 ohms. The input standing wave ratio at all ports shall not exceed 1.15 over the frequency band and service conditions of temperature and humidity. A weather proof box with hinged covers and padlock hasp shall be provided to house all the RF distribution circuits. An AC terminal block shall be provided inside the box for connecting the obstruction lights. In addition, two each weather proof, three wire duplex convenience receptacles shall be mounted on the rear surface of the box.

3.5.5.6 Course width.- Each array shall be capable of providing the course widths specified. This shall be accomplished only by changing the relative power level of the sideband only signal with respect to the carrier signal; no additional equipment or substitution of equipment is permitted.

3.5.5.7 Antenna intercoupling requirements.- The isolation between adjacent antenna elements in the array, as measured between the input connectors of each antenna shall be at least 30 dB. The level of intercoupling shall be such that the measured RF patterns of the array(s) at an ideal unobstructed site shall agree with the theoretical RF patterns within ± 1.0 dB.

3.5.5.8 Integral monitoring.- Integral monitoring signals shall be provided for all arrays which are directly proportional to the radiated signal. The monitoring signals from the elements in each or combined array shall be combined in such a manner that separate RF signals are provided which describe the radiated signal "on-course" and the radiated signal at angles 1.5 to 4.5 degrees "off-course". These monitoring signals so provided shall correlate with the signals that would be obtained with monitoring dipoles at the specified locations in the unobstructed far field. No tuning shall be required in the detector or monitor combining network for changes in frequency or input power. In addition to these specifications, the developed monitor signals shall be of a nature to comply in full with the intent and the specifications for monitoring localizer arrays. A weather proof box with removable cover shall be provided to house the monitor combining unit or at the contractor's option, the combining unit may be housed in the RF distribution unit.

3.5.5.9 Radio frequency energy recombination and detection requirements.- The recombination circuit shall provide proper on-course and off-course output signals (phase and amplitude) with input signal phase relationships of no more than ± 3 degrees

3.5.5.10 Interface circuits.- Course interface circuits shall be provided to accept the inputs from the recombination circuit (on-course and off-course) and provide triplicate outputs for detection and monitor channel inputs. When a two frequency system is used, clearance interface circuits shall be provided to accept the inputs from the clearance recombination circuit (on-course and off-course) and provide duplicate inputs for the clearance "On-Course" monitor channels and triplicate outputs for the clearance "Off-Course" monitor channels.

3.4.4.11 Fault monitor.- Detection devices shall be employed to monitor open and short conditions in any RF transmission line between the distribution circuit(s), recombination circuit(s), and antenna elements that comprise the localizer antenna group.

3.5.5.12 Obstruction marking and lighting.- Double obstruction lights per FAA Advisory Circular AC 150/5345-2 shall be provided for mounting on both ends of the antenna array(s). The lamps in each fixture shall be wired in parallel and shall be rated at 100 watts.

3.5.6 Localizer far field monitor

3.5.6.1 Localizer far field monitor general requirements.- The VHF Localizer subsystem far field monitor shall consist of the following:

(a) Three monitor antennas

(b) Three far field monitor receivers

(c) Three monitor units

(d) Combining/time delay/control circuits

(e) Far field monitor equipment cabinet

(f) Battery shelter equipped with stand-by batteries

(g) Interface cables

The far field monitor antenna array design shall consist of three independent horizontally polarized, directional, minimum 6 dB gain over isotropic, antennas that will normally be located on appropriate support structures at or near the middle marker beacon site. The far field monitor equipment shall be used in conjunction with the Localizer subsystem. Monitored data shall be transmitted to the Localizer station and the remote indication and control point through telephone cable pairs, each pair having a DC loop resistance of approximately 2000 ohms. The far field monitor unit shall operate properly on independent standby power for a minimum of 72 hours after loss of the primary power sourse over the environmental service conditions.

3.5.6.2 Far field monitor receiver performance.- The far field monitor unit shall be equipped with three VHF receivers designed to meet the following requirements over the environmental service conditions:

(a) Frequency range - 108 MHz.

(b) Sensitivity - two microvolts to 10 dB (S+N)/N, 20 percent modulation, 90 Hz.

(c) IF image rejection - 90 dB minimum.

(d) Frequency stability - $\pm$ 35 x 10^{-6}

(e) Localizer channel selector - plug-in crystal

(f) Desensitization - for a desired signal of 5 microvolts, 30 percent modulation, a 4-volt signal at $\pm$ 4 MHz from the desired signal shall cause a loss of gain of no more than 2 dB.

(g) Cross modulation - for a given input signal of 5 microvolts, an undesired signal at 60 dB $\pm$ 50 KHz away modulated at 50 percent shall cause no more than 10 percent distortion.

(h) Selectivity - 15 KHz minimum at -6 dB
35 KHz maximum at -60 dB
60 KHz maximum at -90 dB

(i) Input impedance - 50 ohms $\pm$ 10 ohms.

(j) Frequency response - for 20 percent modulation at 90 Hz and 150 Hz the audio output amplitudes shall be within $\pm$ 0.1 dB of each other.

(k) Audio output - for a 20 microvolt input signal 20 percent modulated at 90 Hz, the output shall be adjustable from 0 to at least 125% of the minimum required for the monitor input.

(l) AGC - The AGC threshold shall be 20 microvolts minimum.

(m) The output shall vary no more than 3 dB as the input is varied from AGC threshold to 10 millivolts.

(n) Percent modulation - The AC output shall vary linearly from zero to 60 percent modulation. The DC output shall not change appreciably as the percent of modulation is varied.

(o) Output impedance - 20 kohms maximum.

(p) Audio distortion - The audio distortion at 90 Hz and 150 Hz shall be no more than 5 percent with an RF input of 50 microvolts to 10 millivolts with modulation levels up to 50 percent.

3.5.6.3 Far field monitor energy combining and monitor logic requirements.- The far field monitor shall provide triplicate channel monitoring of the Localizer course signal for proper alignment. The monitor channels and a combining time delay control panel shall be provided as follows:

(a) Monitor channel.- Three monitor channels shall be provided to monitor the DDM of the 90 Hz and 150 Hz signals and to indicate the DDM both locally and remotely at the Localizer station. The outputs of the monitor channels shall also be used to drive a logic network which shall generate the decisions as to whether or not a fault exists. The far field monitor channels shall be interchangeable with the localizer station monitor channels.

(b) Combining/time delay/control panel.- A combining/time delay/control panel shall be included to perform the following functions:

(1) Combine the monitor channel output DDM information to determine subsystem status as Category III or less at the remote control and indication subsystem.

(2) Trigger localizer shutdown signal after adjustable time delay.

(3) Trigger localizer shutdown alert signal.

(4) Monitor the status of DC/Power supplies.

(5) Monitor the battery charger status.

(6) Monitor the equipment temperature.

Fault in (4), (5), or (6) shall cause an abnormal indication at the Localizer subsystem without initiating changeover to the standby transmitter.

3.5.6.4 Far field monitor equipment cabinet and battery shelters requirements.- The far field monitor electronic subassemblies shall be housed in a double-walled equipment cabinet suitable for mounting on a concrete hardstand. Inner and outer front covers shall also be provided as specified.

(a) Equipment cabinet.- The outer cabinet shall be vented to provide convection cooling of the equipment while simultaneously providing protection against rain and screening against insects. The inner cabinet shall be vented as required

for adequate convection cooling with RF screening as required to meet equipment performance requirements. A duplex convenience outlet shall be installed inside the inner cabinet and shall be wired for 120 VAC operation.

(b) Covers.- The shelter shall be provided with inner and outer covers. The inner cover shall be top-hinged and secured by means of Dzus fasteners (or equivalent) along the bottom and side edges. A movable bar shall be provided to support the cover in a horizontal position as a rain shield. The hinges shall be detachable to permit complete removal of the cover when desired. When positioned as a rain shield, the cover shall not interfere with removal of modules or use of extender cards. The outer cover shall be removable by captive thumb screws. A hasp shall be furnished for attachment of a padlock to prevent unauthorized access to the equipment within the cabinet.

(c) Battery shelter.- An insulated aluminum housing shall be furnished to contain the batteries needed to satisfy the power requirements of the far field monitor and shall be designed for mounting on a platform. It shall provide adequate protection against damage caused by acid spillage. It shall have a hinged door, provide adequate weather protection for the batteries, and shall permit the necessary air flow for ventilation. A hasp shall be furnished for a padlock to preclude unauthorized access to the equipment.

3.5.6.5 Far field monitor prime and standby power requirements.- Primary power for the far field monitor shall be 3-wire, 120/240 volts ac, single phase service. Standby power shall be provided by batteries operating in conjunction with a battery charger/power supply unit specified as follows:

(a) Battery.- The far field monitor shall be equipped with a lead-acid type storage battery or equivalent capable of operation in the temperature range from -10 degrees C to +70 degrees C. The battery shall provide standby operation for a minimum of 72 hours in the event of a primary power failure.

(b) Battery charger/power supply.- A battery charger/power supply unit shall be provided to serve a dual function as follows: In normal operation, the unit shall serve as a power supply for the far field monitor electronic equipment and shall generate a regulated float voltage. If primary power is interrupted for a period of 5 seconds or more, the unit shall automatically switch to an equalize

voltage. After battery discharge the battery charger/power supply unit shall then operate as a battery charger for a minimum period of 24 hours, before automatically reverting back to normal operation. Detailed characteristics are as follows:

(1) Current limiting.- The charger/power supply unit shall be equipped with an adjustable current limiting circuit to provide an output current between the limits of 0 and its capacity.

(2) Protection circuitry.- The input and output lines of the charger/power supply shall be equipped with circuit breakers. A charging diode shall also be incorporated to protect the charger during the period of time that the far-field monitor battery is switched into the circuit and primary power is not available.

(3) Automatic shutdown.- The charger/power supply unit shall include an under-voltage detection switchover unit which shall automatically switch the battery out of the circuit when the battery voltage drops to 80 ± 5% of nominal while the far field monitor is under battery operation. An indicator lamp shall also be provided to indicate when the unit is functioning as a battery charger.

3.5.7 Localizer power requirements

3.5.7.1 Localizer standby power requirements.- A redundant battery/battery charger-power supply shall be provided for subsystem operation. For the purpose of this specification, batteries and power supplies shall be considered as a power system. The battery(s) shall be capable of supplying a full load current for 3 hours at 0 degrees C (32 degrees F) after the charging source has been removed. Minimum life expectancy afloat shall be 5 years. An independent overload protected power source of 60 Hz, 120/240 V, three wire AC power shall be provided for each primary power supply input. Each power supply shall be capable of continuous operation into a worst case subsystem load while raising the battery(s) to full charge condition from a 50-percent discharge within 8 hours. The specified battery(s) shall be capable of sustaining normal subsystem operation for 3 hours after primary power failure. In addition to these requirements, the battery charger-power supply shall meet the following performance requirements, over the environmental service conditions:

(a) Maintain a float-voltage of 2.15 to 2.17 V per cell with a maximum of 200 mV PP ripple with or without a battery attached. Float voltage shall be maintained within ± 5 percent over the load range.

(b) Supply on demand an equalize voltage of 2.30 to 2.33 V per cell with a maximum of 200 mV PP ripple. The equalize mode shall be disabled in the absence of a battery.

(c) Limit output voltage transients to 10 percent of the initial steady-state voltage for conditions of:

(1) a step change of 15 A, from a 5 A or a 20 A load,

(2) input line transients up to ± 10 percent of nominal,

(3) establish regulation within 0.5 percent within 250 ms after passage of transient upset.

(d) Regulation shall be established within 0.5 percent within 6 seconds after turn-on.

(e) Accessible controls shall include:

(1) a manual on-off switch,

(2) a manual load/battery disconnect switch,

(3) float voltage adjustment,

(4) equalize voltage adjustment.

(f) Circuit breaker protection shall be provided as follows:

(1) in line with AC input,

(2) at battery output(s),

(3) at charger output(s) to subsystem and battery.

(g) Visual indication of status shall include:

(1) a DC ammeter for load current,

(2) a red lamp for primary power failure,

(3) a green lamp for primary power operation,

(4) a red lamp for charger failure,

(5) a green lamp for charger operation

(6) an equalization timer with dual scale to indicate 0 to 24 hours

(h) Remote indication and control unit action shall be furnished on condition of:

(1) primary power failure,

(2) power supply failure,

(3) charger output voltage below 105% of nominal battery voltage and

(4) battery terminal voltage below 90 ± 2% of nominal.

3.5.7.2 Localizer standby interface power requirements.- Standby power will be continuously available. In addition, automatic operation of switching devices shall afford the following:

(a) disconnection of the battery from the load when terminal voltage drops 80 ± 5% of nominal,

(b) disconnection of power supply when output exceeds 120 ± 5% of nominal.

3.5.7.3 Localizer battery enclosure.- A non-corrosive battery box(s) shall be provided. This box shall contain the standby power supply batteries and shall be easily accessible. The battery box shall be vented to the environment external to the Localizer equipment shelter to prevent accumulation of potentially explosive gasses. The battery box shall be constructed so as to prevent damage to the Localizer equipment shelter resulting from spilled electrolyte. A battery box located outside of the equipment shelter is permissible.

3.5.8 Localizer Interconnections

3.5.8.1 RF cables requirements.- The RF cables utilized in this subsystem shall be in accordance with paragraph 1-9.10.7, FAA-G-2100/1.

3.6 UHF Glide Slope subsystem

3.6.1 Glide Slope general requirements.- The Glide Slope subsystem shall be so designed as to allow field conversion between either a two frequency (capture effect) configuration or a possible single frequency (null reference) configuration. Conversion shall be by adding modular equipments and cabling to a single frequency design

or by deleting modular equipments and cabling from a two frequency design. The Glide Slope subsystem shall be deliverable in either configuration, as defined by the Contract Officer. A completely equipped Glide Slope subsystem shall consist of the following:

(a) One-frequency (null reference) configuration:

(1) Dual Transmitter group with associated modulation, control, and automatic change over equipment.

(2) One complete Glide Slope antenna group of two identical directional transmitting antennas, including power divider networks, with integral monitoring probes, and combining networks, associated cabling and a 40-foot tower. The tower shall be sectionalized, consisting of two 15-foot sections and one-10 foot section.

(3) One Glide Slope monitor group, including a single on-path monitor antenna, a monitor support mast, and three sets of detectors, as required.

(4) One shelter group complete with electrical wiring and environmental controls as specified in 3.4.10.

(b) Two-frequency (capture effect) configuration. A complete capture effect subsystem shall consist of the equipment described in 3.6.1(a) plus the following items.

(1) One additional Glide Slope antenna (including power divider network, integral monitor probe, combining network, and cabling) of the same type provided for a null reference facility.

(2) Two clearance transmitters.

(3) One 15-foot tower sections to increase the height of the antenna tower of 3.6.1(a) to a maximum of 55 feet.

(4) Clearance signal monitor.

3.6.2 Glide Slope operational requirements.- The UHF Glide Slope subsystem shall provide guidance in the vertical plane to aircraft engaging in approaches to and landings at airfields. The radiation from the UHF Glide Slope antenna group shall produce a composite field pattern that is amplitude modulated by 90 Hz and 150 Hz tones. The Glide Slope subsystem shall be capable of adjustment to produce glide path angles between two and four degrees. The pattern shall be arranged to provide a straight line descent path in the vertical plane containing the runway centerline, with the 150 Hz tone predominating below the path and the 90 Hz tone predominating above the

path, to at least an angle equal to 1.75 times the glide slope angle. The glide path angle shall be maintained within .12 degrees from the commissioned glide path angle. The downward extended straight portion of the ILS glide path shall pass through the ILS reference datum at a height ensuring safe and efficient use of the runway served. This height, at runway threshold shall be a nominal 50 feet, but shall not fall outside the limits of 47 to 60 feet. The difference between glide path angles by redundant transmitters shall not exceed 0.10 degrees.

3.6.2.1 Operational radio frequencies.- The UHF Glide Slope subsystem shall be inherently capable of operating on any carrier frequency in 0.150 MHz increments within the operational band of 328.6 to 335.4 MHz without basic design changes. The frequency tolerance shall not exceed ±.002 percent.

The UHF Glide Slope subsystem, as provided, shall operate on one of the selected operational carriers as listed in Table 2 - - Glide Slope Operational Frequencies. The operational frequency shall be specified at time of contract award. The operation of the UHF Glide Slope subsystem at the different frequencies as listed in Table 2 may require substitution of modular devices. To alter the operational carrier frequency, the UHF Glide Slope subsystem shall be capable of being modified by modular substitution only. To change the operational carrier frequency, only adjustments which are considered to be of a field level nature shall be required. If a two-frequency (capture effect) configuration is employed, the frequencies of the RF carriers shall be individually adjustable and the band occupied by the carriers shall be symmetrical about the assigned frequency. The frequency separation between the carriers shall not be less than seven (7) or more than nine (9) kHz over the environmental service conditions, with all tolerances applied.

TABLE 2

GLIDE SLOPE OPERATIONAL FREQUENCIES (MHz)

334.7	33.14	334.4	331.7
334.55	331.25	334.25	331.55
334.1	332.0	333.0	332.3
333.95	331.85	334.85	332.15
329.9	332.6	329.6	332.9
329.75	332.45	329.45	332.75
	333.2		
330.5	333.05	330.2	333.5

		330.05	333.3
330.35	333.80	330.8	331.1
329.3			
329.15	333.65	330.65	330.95

3.6.2.2 RF pattern coverage.- The Glide Slope subsystem shall provide signals sufficient to allow satisfactory operation of a typical aircraft installation with the transmitter power output reduced to the monitor RF level alarm. The sector of operation shall be eight degrees on each side of the runway centerline extended to a distance of at least 10 nautical miles up to 1.75θ and down to 0.3θ. Below 0.3θ to the limit of coverage, it shall provide a minimum of 0.22 DDM fly up. The requirements of Annex 10, Part I para. 3.1.4.3.2 are also applicable.

3.6.2.3 Polarization.- The emission from the Glide Slope antenna array shall be horizontally polarized.

3.6.2.4 Modulation.- The nominal depth of modulation of the RF carrier due to each of the 90 Hz and 150 Hz tones shall be 40 percent along ILS glide path and the depth of modulation shall be maintained within the limits of 37.5 and 42.5 percent.

3.6.2.5 Displacement sensitivity and below path coverage.- The angular displacement sensitivity shall be symmetrical. The nominal angular displacement sensitivity shall correspond to a DDM of 0.0875 at an angular displacement of 0.35 degrees above and below the glide path. This value corresponds to a deflection of $\pm$ 75 microamperes. The DDM below the ILS glide path shall increase smoothly for decreasing angle until a value of 0.22 DDM is reached. This corresponds to a "fly-up" deviation of 190 microamperes. This value shall be achieved at an angle of not less than 0.3θ of the Glide Slope angle above the horizontal. However, if it is achieved at an angle greater than 0.45 of the Glide Slope angle, the DDM shall remain equal to or greater than 0.22 DDM down to 0.3 of the Glide Slope angle or to the limit of the coverage whichever is lower. The glide path width and angle shall be so adjusted that an aircraft flying in such a way as to just clear all obstructions between the outer marker and the threshold obtains a signal of no less than 180 microamperes (0.21 DDM) "fly-up." With the glide path widened or lowered to the alarm point, no less than 150 microamperes (0.175 DDM) shall be obtained. The angular displacement sensitivity shall be adjusted and maintained within $\pm$ 15 percent of the nominal value selected.

3.6.2.6 Glide Slope subsystem site criteria.- The Glide Slope subsystem shall be so designed as to allow proper operation at a location no closer than 400-feet to the Category III runway centerline and shall not exceed 55-feet in height above the elevation of the runway centerline nearest it. A mast of over 55-feet may be permitted if the minimum distance from the runway centerline is increased by 10-feet for each foot the mast height exceeds 55 feet in height.

3.6.3 Glide Slope transmitter group

3.6.3.1 Glide Slope transmitter group general requirements.- The UHF transmitter group shall be composed of those equipments involved in the generation, regulation, amplification and modulation of glide path signals by dual systems interchangeable in main or standby functions. While the designated main system is operating into the antenna group the designated standby system shall be operating under monitor system control into dummy loads through the changeover-test assembly. Immediate changeover shall be effected automatically on command on the monitor system or by manual override.

3.6.3.2 Glide Slope transmitter performance.- The same transmitter units shall be employed in either capture effect or null reference Glide Slope subsystems. It shall be crystal oscillator controlled and shall be capable of tuning all assigned Glide Slope frequencies within the range of 328 MHz to 336 MHz, with continuously adjustable output power, rejection of harmonic frequencies and noise, and the modulation characteristics as specified under this paragraph. The same transmitter type shall be capable of serving either course or clearance signal generation functions.

Both the course and the clearance transmitter (capture effect configuration only) shall perform as follows over the environmental service conditions.

3.6.3.3 Transmitter output power.- The transmitter carrier output power, at all operating frequencies, shall be adjustable from 10% to 150% of that required to meet coverage adjustment specified. Adjustment of at least 40 percent to 100 percent of the rated transmitter output power over this range shall not change the modulation balance by more than 0.002 DDM or the course width by more than 2.0 percent. Adjustments over the range from 10 percent to 100 percent of rated power output shall not change the modulation percentage more than two percent for settings of 50 to 97 percent by a 150 Hz modulating tone. Power output shall not vary more than ± 10 percent with DC operating voltage variations of ± 15 percent.

3.6.3.4 Transmitter stability.- When adjusted under normal test conditions for optimum transmitter conditions, changes in the following parameters over the service conditions shall not exceed:

(a)	Carrier power at carrier output	± 10 percent
(b)	Sideband ratio	± 5 dB
(c)	Carrier modulation	± 2 percent (each tone)
(d)	Carrier modulation balance	± 0.015 DDM
(e)	Sideband balance	± 0.05 dB
(f)	RF phase between carrier and sideband outputs	± 10 degrees
(g)	Navigational tone frequencies	± 1.0 percent
(h)	Transmitter frequency	± .002 percent of the assigned frequency

The above requirements shall be met throughout all positions of the sideband amplitude control.

3.6.3.5 Stabilization time.- After initial adjustment under normal test conditions, changes from the initial room temperature readings occurring between three seconds and 15 minutes after initial application of power under each of steps 3, 6, and 8 of 1.4.12 of Specification FAA-G-2100/1 (modified 1-4.12 for this application) shall not exceed the limits tabulated below. The readings for each parameter shall not exceed the limits tabulated below. The readings for each parameter shall be taken at three seconds after being energized, and on a continuous recording basis for 15 minutes after being energized.

(a)	Carrier power at carrier output	± 10 percent
(b)	Sideband ratio	±0.5 dB
(c)	Carrier modulation	±.50 percent (each tone)
(d)	Carrier Modulation balance	± 0.01 DDM
(e)	Sideband balance	± 0.5 dB
(f)	RF phase between carrier and sideband outputs	± 10 degrees

(g)	Navigational tone frequencies	± 1 percent
(h)	Transmitter frequency	±.0002 percent of the assigned frequency

The above requirements shall be met at all positions of the sideband amplitude control.

3.6.3.6 Control functions.- A switch shall be provided to turn the transmitter output radiation on and off. In addition, it shall be possible to select either local or remote control of this function.

3.6.3.7 Crystal.- Two of each channel determining crystal shall be furnished with each transmitter in accordance with a listing of channel frequency assignments which will be furnished by the Government. In order to change the transmitter frequency, the crystal shall be the only component requiring replacement. The crystal shall be easily removable from a plug-in socket. Crystals supplied for capture effect systems shall provide for operation 4 KHz above the assigned frequency for the course transmitter and 4 KHz below the assigned frequency for the clearance transmitter.

3.6.3.8 Crystal oven. A crystal oven shall not be used.

3.6.3.9 Crystal oscillator stability.- Crystal oscillators and related components shall be selected to ensure output frequency stability within ± 2 ppm over Environment II service conditions and DC supply voltage variations of ± 15%.

3.6.3.10 Resonance points.- There shall be no indication of more than one resonance point over the complete range of travel of adjustment for all controls normally used in tuning or adjusting the transmitter to meet equipment specification requirements. This requirement shall be met over the specified frequency range either during the procedure of tuning the transmitter or after all stages are tuned to resonance, regardless of the transmitter power output.

3.6.3.11 Indicator lights.- Indicator lights shall be provided and mounted on the front panel or the RF module to indicate the application of power and local remote control.

3.6.3.12 Modulation.- A continuously adjustable control shall be provided to permit adjustment of modulation to all values between 50 and 97 percent. The modulated 150 Hz for the separate clearance transmitter, if used, shall be phase locked with the 150 Hz modulation from the reference transmitter.

3.6.3.13 Glide Slope Modulator.- The modulator assembly shall be capable of generation and synchronization of 90 Hz and 150 Hz sine wave tones and amplitude modulation of the radio frequency carrier with these tones.

3.6.3.14 Modulator assembly design.- The modulator assembly shall provide (1) an output containing the RF carrier modulated by the navigation tones and (2) an output containing only the separate sideband frequencies of the navigation tones (3) 150 Hz source for modulation of the clearance transmitter in the Capture effect configuration. Mechanical modulation techniques shall not be employed in the design of the modulator. Input/output impedance shall be nominal 50 ohms and the input VSWR shall not exceed 1.15:1.

3.6.3.15 Modulation tones.- The modulating tones shall be 90 Hz and 150 Hz within ± 1.0 percent.

3.6.3.16 Audio phase of modulation tones.- The modulating tones shall be so phase-locked that the demondulated 90 and 150 Hz signals appearing at the carrier output pass through zero within 50 microseconds of each other in the same direction, every 1/30 second.

3.6.3.17 Carrier modulation.- Modulation of the carrier output signals over a minimum range of 36 to 44 percent shall be accomplished by the use of a continuously adjustable control which shall not produce a change of more than ± five degrees in RF phase between carrier and sideband outputs as measured over the service conditions. Adjustment of the modulation control over the range specified herein shall have no effect on path structure or symmetry of path width.

3.6.3.18 Modulation balance adjustment.- A continuously adjustable control shall be provided for precisely adjusting the total modulation balance. Throughout the range of adjustment of the modulation percentage control, and without making any other adjustments within the modulator, adjustment of the modulation balance control shall provide total modulation balance.

3.6.3.19 Sideband amplitude control.- A sideband amplitude control shall be provided to enable adjustment of the glide path full sector width over the range of 0.80 degrees to 2.0 degrees. Adjustment of this control over its full range shall not cause the phase to change more than ± 5 degrees.

3.6.3.20 RF phaser control.- A continuously adjustable phasing control shall be provided for shifting the RF phase of the signals appearing at the carrier output over a range of at least ± 30 degrees from normal.

3.6.3.21 Modulator navigation tone control.- A control shall be provided to enable independent removal of the navigation tones from the RF carrier.

3.6.3.22 Modulator test circuit.- For test purposes, a minimum of four identical linear detectors for sampling the respective signals of the carrier output, sideband output, 90 Hz output and 150 Hz output shall be provided. The output of each of the linear detectors shall be a minimum of 300 millivolts into a 20 K ohm load and shall be available at type BNC coaxial connector test jacks.

3.6.3.23 Carrier signal at sideband output.- With the modulator adjusted for optimum conditions, for any combination of sideband amplitude control or sideband phaser control settings, the carrier power appearing at the sideband output shall be 40 dB or more below the carrier power appearing at carrier output when measured over the service conditions of temperature and humidity.

3.6.3.24 Distortion of demodulated navigation tones.- With the equipment adjusted for optimum conditions, the signals appearing at the Carrier Output and Sideband Output front panel test jacks shall be such as to produce a demodulated signal with equal 90 and 150 Hz components and distortion components which do not exceed the following.

Frequency	Distortion component referred to 90 or 150 Hz signal
180 Hz	3 percent
270 Hz	4 percent
300 Hz	4 percent
450 Hz	4 percent
All other frequencies within the range of 30 to 4000 Hz	2 percent

In addition, the total harmonic distortion shall not exceed 8 percent. The above distortion requirements shall also be met when the input power to the modulator is varied over the specified range of the transmitter power output.

3.6.3.25 Capture effect amplitude and phase control assembly.- (Used with capture effect GS configuration only.) The capture effect amplitude and phase control assembly shall be designed to combine the separate carrier, sideband and clearance signals from the glide slope and clearance transmitters in the appropriate amplitude and phase relationship for delivery to three transmitting antennas. Carrier signals will be radiated from the lower and middle antennas, sideband signals from all three antennas and clearance signals from the upper and lower antennas.

(a) Impedance shall be a nominal 50 ohms at all RF ports.

(b) VSWR shall not exceed 1.15:1, at each port, all other ports terminated into 50 ohms.

3.6.3.26 Capture effect amplitude control.- Continuously adjustable controls shall be provided to divide the power as required to:

(a) Establish the proper ratio of the carrier power delivered to the lower and middle antenna outputs.

(b) Establish proper ratio of sideband power delivered to the upper and lower antenna outputs.

(c) Establish the proper ratio of the sideband power delivered to the middle antenna output with respect to the upper and lower antenna outputs.

Adjustment of each power divider throughout its range shall not change the RF phase at the antenna outputs by more than ± 2.0 degrees.

3.6.3.27 Capture Effect Phase Control.- The phase of the upper antenna output shall be in phase (± 5.0 degrees) with respect to the lower antenna output and simultaneously out-of-phase (180 ± 5.0 degrees) with respect to the middle antenna output.

3.6.3.28 Capture effect carrier isolation.- With each phaser and power divider set to midrange the power at the upper antenna output, the sideband input and the clearance input shall be 40 dB or more below the incident power applied to the carrier input.

3.6.3.29 Capture effect carrier stability.- After initial adjustment under normal test conditions, the ratio of the power at the middle antenna output with respect to the power at the low antenna output shall not vary more than ± 0.5 dB over the service conditions of temperature and humidity. Additionally the phase of the signal at the middle antenna output shall not vary more than ± 5.0 degrees with respect to the phase of the signal at the lower antenna output as measured over the service conditions of temperature and humidity.

3.6.3.30 Capture effect sideband isolation.- With each phaser and power divider set to midrange, the power at the carrier input shall be 40 dB or more below the incident power applied to the sideband input. The power at the clearance input shall be 33 dB or more below the incident power applied to the sideband input.

3.6.3.31 Capture effect sideband stability.- After initial adjustment under normal test conditions, the ratio of the power at the upper, middle and lower antenna signal outputs each with respect to the power of every other output shall not vary more than ± 0.5 dB under the service conditions of temperature and humidity. The sum

of the powers at the upper, middle and lower antenna outputs shall not vary more than ± 0.5 dB. Additionally, the phase of the sideband signal at the upper, middle and lower antenna each with respect to every other output shall not vary more than ± 5.0 degrees and the phase of the sideband signal with respect to the carrier signal at the middle and lower antenna signal output shall not vary more than ± 5.0 degrees.

3.6.3.32 Capture effect clearance isolation.- With all phasers and power dividers set to midscale, the power at the carrier input, sideband input and middle antenna output shall be 33 dB or more below the incident power applied to the clearance input.

3.6.3.33 Equipment changeover and test requirements.- Changeover circuits shall be used to connect the antenna group to the principal or standby transmitter channel on command of the control unit. Thru-line wattmeter line sections shall permit testing of waveforms and power levels of the signals at each antenna cable input for maintenance. Phase adjusters shall be provided in each line for alignment purposes, while phase and power corrected outputs from the designated standby transmitter(s) modulator are continuously monitored for operational readiness. Through-line sections shall also be provided for measuring signal inputs to the distribution unit. Changeover and test performance shall be as follows over the environmental service conditions:

(a) Impedance shall be nominal 50 ohms at all RF ports.

(b) Insertion loss shall not exceed 0.4 dB.

(c) Switching time to switch the standby transmitters to the antenna array shall not exceed 300 milliseconds (ms) after command of monitor control.

(d) VSWR shall not exceed 1.15:1.

(e) Phase error due to internal line lengths shall not exceed ± 2 degrees.

(f) Any RF signal radiated from the standby equipment shall be at least 50 dB below the carrier level of the main unit as measured at the input to the antenna group.

3.6.3.34 R.F. Phasers.- Phasers shall be provided in each of the antenna outputs. Each phaser shall have an electrical range of adjustment of at least 60 degrees each side of midscale. Phasers shall be furnished for capture effect and null reference configurations.

3.6.4 Glide Slope control and monitoring

3.6.4.1 Monitoring general requirements.- The Glide Slope subsystem shall be equipped with a high integrity monitor group for fault detection. Automatic switchover or shutdown shall be initiated on command of the monitor group when critical parameters exceed specified limits. The monitor group shall be capable of operation in conjunction with a remote indicator/control unit providing audible and visual indication of subsystem status and complete, positive control over this subsystem. The Glide Slope subsystem shall have triple monitors such that each specified parameter radiated (path width path position and capture effect Glide Slope clearance) is examined by three identical monitor channels including detectors, with inputs in parallel. Two identical monitor channels shall alarm before shutdown or transfer is initiated. The standby transmitter shall be monitored by single monitors for RF, SDM and DDM. An out-of-tolerance alarm at a single monitor or loss of the standby transmitters shall produce indications of abnormal operation. The total period of radiation outside the performance limits shall not exceed 1 second. Any of the following conditions shall cause transfer or shutdown as appropriate.

(a) A shift of the mean glide path by more than $\pm$ 0.2°.

(b) A reduction of power output to less than 50 percent for single frequency (null reference) or either carrier to less than 80 percent for two frequency (capture effect) of nominal radiation, or to any point causing the guidance signal to fall outside the specified limits.

(c) A change in path half sector width exceeding $\pm$ 0.2 degrees from nominal.

(d) A lowering of the line below the glide path at which a DDM of 0.0875 is realized to an angle less than 0.7480 from the horizontal.

(e) Deterioration of the Glide Slope subsystem that would result in the reduction of below-path clearances outside the specified limits of 3.6.2.5.

(f) A change in sum of modulation percentages (SDM) outside the limits of 80 $\pm$ 4 percent.

(g) Antenna mast misalignment.

The standby transmitter monitor shall monitor (except the misalignment monitor) conditions (a) through (f) above for the Standby transmitter(s). Monitor channels throughout the Glide Slope subsystem shall be functionally and mechanically interchangeable and shall simultaneously monitor the DDM, SDM and RF level of the detected signal. Circuit conditions shall be manually adjustable within the basic monitor channel by means of programming jumpers or switches and potentiometer settings. A suitable meter or meters and circuitry shall be provided in the equipment cabinet or in individual channels to allow final calibration of the monitor channel in place, and self test switches or circuitry as required shall force conditions essential to adjustment. Monitor channel front panel lamps shall indicate on line condition and memorized alarms from DDM, SDM and RF detection logic. Interface requirements for the individual monitor channel shall include:

(a) DC level proportional to DDM, SDM and RF levels shall be provided and available to the interface for maintenance monitor pre-alarm generation and/or recorder inputs.

(b) Individual DDM, SDM and RF level alarms shall be placed on the interface as logic levels, and shall be latched until reset from an extension control circuit. A general alarm output shall be the logical OR of DDM, SDM and RF alarms. Front panel lamps or other devices at the individual monitor channel shall indicate the presence of a memorized fault as well as a power on condition.

3.6.4.2 Glide Slope monitor fail-safe.- The Glide Slope monitor shall be fail-safe such that failure of any part of the monitor shall either result directly in an alarm condition, or as a minimum, shall not alter any alarm threshold level in the direction of tolerating greater deterioration of the transmitter output characteristics than permitted in the absence of such failures. For such parts as electronic or electromagnetic switching devices where it is not practical to provide fail-safe operation under both modes of failure (open circuit and short circuit), fail-safe protection shall be provided for the mode of failure having the higher probability.

3.6.4.3 Glide Slope monitor stabilization.- All monitor channels shall be stabilized within 2 seconds after initial application of radiated signals. Concurrently, internal monitor control action shall begin within 2 seconds after initial application of radiated signals when such signals are outside of allowable tolerances. Interaction of all the monitor parameters shall be minimized allowing simple straightforward adjustments of all monitor parameters in turn with minimum readjustment.

3.6.4.4 Near field monitor action.- Monitor alarms from two of three monitors at the near field monitor shall act to stop all radiation from the Glide Slope subsystem. An adjustable time delay of from 2 to 10 seconds (nominally 2 seconds) shall be provided. The near field monitor general requirements shall be those specified under 3.6.6.

3.6.4.5 Integral monitor action.- Upon detection of radiation faults by at least two of three monitor channels of the same parameter in the integral monitor system, the control unit shall initiate the following action:

(a) Immediately cease radiation by the principal Glide Slope transmitter.

(b) Immediately switch to the operating standby unit, if available or cease radiation entirely if standby unit not available.

(c) Upon transfer or shutdown, action shall initiate an audible and visual alarm at the remote control-indicator unit and a visible alarm at the Glide Slope facility.

(d) If the fault persists after changeover, the control units shall automatically cause all Glide Slope radiation to cease and shall prevent restoration for a period of at least 20 seconds. From this condition, manual restart shall be required.

3.6.4.6 Standby monitor action.- Monitor alarms from any monitor of standby transmitter operation shall, after an adjustable delay of from 2 to 5 seconds, cause shutdown of the standby transmitter.

3.6.4.7 Antenna misalignment monitor.- Misalignment of the antenna tower by a nominal angle of 30 minutes from the vertical, in any direction, persisting for a time period adjustable between 120 and 150 seconds, shall cause all Glide Slope radiation to cease. This angle corresponds to a nominal 5-inch displacement at the top of a 55-foot tower. It shall be possible to bypass separately the misalignment detector alarm.

3.6.4.8 Transmitter environment monitor.- An abnormal environment indicator shall light at the remote control indicator if the transmitter environment becomes more than 15 degrees C beyond the normal range of temperature maintained by the heater and air conditioner. Environment alarms shall be indicated by equipment cabinet panel lamps and shall be summed in the control unit and shall provide an abnormal indication at the remote indication and control unit.

3.6.4.9 Transmitter prime power monitor action.- An abnormal power indicator shall light at the remote control indicator if power conditions within the subsystem deteriorate such that:

(1) AC primary power fails

(2) Battery/battery charger line voltage falls outside the limits of ± 15%.

3.6.4.10 Monitor display requirements.- Provisions shall be made for meter indications and status indicating lights for all parameters monitored. Meters shall be so calibrated that readings may be used directly to ascertain correct values of course alignment and width.

3.6.4.11 Glide Slope indication and control general requirements.- Monitor outputs shall be maintained to indicate visually the existence of an out of tolerance condition, automatically transfer to standby transmitter, cause downgrade of facility performance status at the remote indicator unit or shut down all radiation, singly or in combination. In addition, any indication given or action taken shall be memorized at the equipment panel. Time delay circuitry, indicator drivers and power/environment sensors shall be considered part of the indication and control unit.

3.6.4.12 Memorization of monitor functions.- A means of memorization or non-memorization of the monitor channel DDM, SDM, RF, and antenna mast misalignment alarms shall be provided by the indication and control unit. A means shall be provided to clear the memorized alarm without affecting facility operation.

3.6.4.13 Transmitter selection control requirements.- The control unit shall provide selection of either transmitter 1 or transmitter 2 as the main transmitter.

3.6.4.14 Monitor mismatch action.- A monitor mismatch indication shall be provided when any single monitor channel in any integral or near field monitor activates an alarm. This action shall also light the abnormal conditions warning indicator.

3.6.4.15 Remote control interface requirements.- Interface requirements between the Glide Slope subsystem and the remote indicator and control unit shall be provided.

3.6.4.16 Press to test light requirements.- The indication and control unit shall provide a means of testing all lamp bulbs on the monitor channels and on the indication panel by operation of a momentary switch.

3.6.4.17 Monitor bypass requirements.- The indication and control unit shall have an override switch that disables monitor action during periods of adjustment and maintenance.

3.6.4.18 Abnormal conditions warning.- An abnormal condition indicator at the indication and control unit shall light if any one or more of the following conditions occur:

(a) Subsystem off the air

(b) Standby transmitter on the air

(c) Standby transmitter power off

(d) Monitor mismatch

(e) Monitor locally bypassed

(f) Antenna tower mis-alignment greater than one-half of one degree

(g) Monitor alarm

(h) Power/environment alarm

3.6.4.19 Additional indication and control unit provisions.- In addition to the actions previously listed the indication and control unit shall provide.

(a) On-off status displays for the main and standby transmitters.

(b) A selection between local and remote transmitter ON-OFF controls.

(c) A forced 20-second delay before a manual restart after automatic shutdown of both transmitters.

(d) An off indicating light (in addition to abnormal lights) when the subsystem is off the air.

3.6.5 Glide Slope Antenna group

3.6.5.1 Glide Slope antenna general requirements.- The null reference Glide Slope antenna array shall consist of two identical antennas. The capture effect Glide Slope antenna array will consist of three identical antennas and these shall be of the same design as those antennas proposed for the null reference type equipment. All antennas shall be interchangeable.

3.6.5.2 Glide Slope antenna group performance.- The antenna group shall be so designed as to provide a maximum of plus and minus 15 degrees beam width as measured at the half-power points. The front hemisphere horizontal pattern of the antenna when plotted as illustrated in Figure 2 shall be confined within the upper and lower limits specified thereon. Each antenna (two for null reference configurations, three for capture effect) shall consist of antenna elements, signal sampling probes and a non metalic radome if required to meet environmental conditions. Power division as opposed to impedance division, shall be employed to distribute energy to the separate antenna elements. Antennas and distribution circuits shall have broadband characteristics to eliminate the necessity for matching adjustment. Each of the antenna units shall meet the following requirements:

(a) Polarization.- The radiated signal of the antenna shall be horizontally polarized. The vertical component shall be at least 25 dB below the horizontally components as measured in front of the antenna and within ± 25 degrees in azimuth of a vertical plane perpendicular to the antenna and passing through the center of the antenna.

(b) Gain.- The gain of the antenna shall be such that the free space radiation from the antenna at zero degrees in azimuth shall be at least 10 dB above that of a lossless isotropic radiator.

(c) Characteristic impedance.- The design center impedance of the components and assemblies shall be 50 ohms.

(d) Front-to-back ratio.- The front-to-back ratio of radiated signals shall be at least 25 dB.

(e) VSWR.- The imput VSWR of the antenna shall not exceed 1.15 under normal test conditions with the antenna fed from a 50-ohm line.

3.6.5.3 Antenna mounting and tower structural requirements.- Each of the identical antenna units shall consist of a radiating array and integral monitor proximity probes.

(a) Antenna mounting.- The antenna shall include mounting provisions to enable vertical mounting on the tower to produce Glide Slope angles between 2 and 4 degrees. Means shall also be provided to laterally offset the antennas, in 1-inch increments, a total of ± 18 inches from its centered position on the tower.

(b) Antenna towers.- The Glide Slope antennas shall be mounted on a steel triangular-shaped sectionalized tower. The forward facing (toward the approach end of the runway) side of the tower shall be perpendicular to the runway centerline at the nearest point on the runway opposite the tower. This side of

the tower shall be perpendicular, whether or not the tower is of uniform size of tapers. Each tower shall be complete with a ladder with uniformly spaced steps, a minimum of 16" wide and maximum of 12" apart, climbing safety equipment per PR-S-001301, double obstruction lights, lightning rods, misalignment detectors anchor bolts and other related hardware. The tower shall be self supporting and the tower height shall be a function of subsystem configuration and shall be designed in accordance with the height limitations specified. Basic tower sections shall be capable of interchange to create either null reference or capture effect configuration.

(c) Radomes.- Radomes, if utilized shall be fabricated of Type II glass fibre base plastic material in accordance with L-P-383 (modifies paragraph 1-3.15.3 of FAA-G-2100/1). If radomes are utilized, all performance requirements of the antenna system shall be met with radomes installed.

(d) Siting criteria.- The design location and height of the Glide Slope antenna shall be in accordance with FAA handbook 6750.16. The maximum height of the Glide Slope antenna tower shall not exceed 60-feet.

3.6.5.4 Radio frequency energy distribution.- If multiple elements are used, an integral distribution network shall be provided for feeding the individual elements of the antenna in the phase and amplitude required. This network shall be weatherproof and mounted in the location on the antenna assembly which is readily accessible for servicing.

3.6.5.5 Integral monitor.- Each of the identical antenna units shall include integral monitor proximity probes capable of adjustment for phasing and power pickoff.

3.6.5.6 RF energy recombining and detection requirements.- Radiated energies sampled by the integral monitor proximity probes shall be summed in suitable broadband networks, then divided by similar networks into complex signals analogous of the antenna system radiation pattern. Detection shall be employed to produce three (for capture effect) or two (for null reference) DC offset audio signals in triplicate for monitor channel inputs. Detection may be incorporated as part of the monitor channel. Three course position, three sensitivity and (if capture effect) three clearance monitor inputs shall be generated. Detection of the composite RF ILS waveform shall be accomplished by units identical in design whether located in the antenna combination circuits or in the UHF changeover and test assembly.

3.6.5.7 Obstruction lighting.- A double obstruction light in accordance with FAA Advisory Circular AC 150/5345-2 shall be provided at the top of the tower. The lamps shall be wired in parallel and shall be rated at 100 watts each.

3.6.5.8 Environmental requirements.- The Glide Slope subsystem, antenna group, and all equipment that comprised this group shall be designed and manufactured to meet the applicable environmental service conditions that are specified.

3.6.6 Glide Slope near field monitor.

3.6.6.1 Near-field monitor general requirements.- A means shall be provided for the interception and monitoring of the radiated Glide Slope signal for the detection of an out-of-tolerance glide path angle. The near field detector shall consist of an environment protected antenna, a suitable tower and electronic detection assemblies, furnished for installation in the radiation field.

3.6.6.2 Near-field monitor performance.- The near-field monitor antenna assembly shall have high forward gain characteristics to minimize affects of aircraft overflights. VSWR shall not exceed 1.15:1 at a nominal 50-ohm unbalanced input.

3.6.6.3 Near-field monitor action.- The near-field monitor shall provide triplicate channel monitoring of the DDM and SDM parameters of the composite ILS Glide Slope waveform. Monitor alarms from two of three monitors at the near field monitor shall stop radiation from the Glide Slope subsystem without attempted transmitter changeover. An adjustable 2 to 10 second delay at the monitor system control unit shall delay station shutdown to avoid disruption by vehicles, while allowing the course integral monitor to effect changeover the standby transmitter due to a failure of system electronics.

3.6.6.4 Near-field monitor location.- The field detector antenna shall be located facing the Glide Slope radiating antenna on a line paralleling the runway centerline. Final location along this line, as well as antenna height, shall be established after flight test of the Glide Slope subsystem, and will vary with assigned frequency, glide path angle, and type of service.

(a) For capture effect service, location of the detector/antenna pad relative to the transmitting antenna base shall be selected within a range of 150 to 390 feet. The antenna height shall be adjustable for all glide paths established between 2 to 4 degrees.

(b) For null reference service, location shall be selected within a range of from 112 to 460 feet and antenna height shall be adjustable for glide paths established between 2.0 and 4.0 degrees. Final adjustment shall place the receiving antenna at the point of nominal 0 DDM in space, at the 180 degree proximity phase point.

3.6.6.5 Near-field monitor detector circuits and adjustment requirements.-

(a) Detector circuits.- Detector circuits shall consist of a three-way signal divider and three RF detectors. If not included as part of the monitor channels, the detector circuits shall be housed in a suitable protective box or cabinet for environmental protection.

The detector outputs shall enter the monitor system at the equipment cabinet monitor channels designated for this purpose.

(b) Monitor adjustment.- DDM monitoring performed by the near field monitor channels shall be accomplished in a like manner as for the integral course monitor channels. SDM alarm points shall be adjusted to wider limits, nominally ±4 percent.

3.6.6.6 Near-field monitor environmental requirements.- The UHF Glide Slope subsystem near field monitor equipment shall be designed and manufactured to meet the specified service conditions.

3.6.7 Glide Slope power requirements.-

3.6.7.1 Glide Slope standby power requirements.- A redundant battery/battery charger-power supply system shall be provided for system operation. For the purpose of this specification batteries and power supplies shall be considered as a power system. The battery(s) shall be capable of supplying a full load current for 3 hours at 0 degrees C (32 degrees F) after the charging source has been removed. Minimum life expectance in float mode shall be 5 years. An independent overload protected power source of 60 Hz, 120/240 V, three-wire AC power shall be provided for each primary power supply input. Each power supply shall be capable of continuous operation into a worst case system load while raising the battery(s) to full charge condition from a 50 percent discharge within 8 hours. The specified batteries shall be capable of sustaining normal system operation for 3 hours after primary power failure. In addition to these requirements, the battery charger-power supply shall meet the following performance requirements over the service conditions.

(a) Maintain a float voltage of 2.15 to 2.17 V per cell with a maximum of 200 mV PP ripple with or without a battery attached. Float voltage shall be maintained within ±5 percent over the load range.

(b) Supply on demand an equalize voltage of 2.30 to 2.33 V per cell with a maximum of 200 mV PP ripple. The equalize mode shall be disabled in the absence of a battery.

(c) Limit output voltage transients to 10 percent of the initial steady-state voltage for conditions of :

(1) a step change of 15 A, from a 5 A or a 20 A load

(2) input line transients up to ±10 percent of nominal

(3) establish regulations within 0.5 percent within 250 ms after passage of transient upset

(d) Regulation shall be established within 0.5 percent within 6 seconds after turn-on.

(e) Accessible controls shall include:

(1) a manual on-off switch

(2) a manual load/battery disconnect switch

(3) float voltage adjustment

(4) equalize voltage adjustment

(f) Circuit breaker protection shall be provided as follows:

(1) in-line with AC input

(2) battery output(s)

(3) charger output(s) to the subsystem and battery

(g) Visual indication of status shall include:

(1) a DC ammeter for load current

(2) a red lamp for primary power failure

(3) a green lamp for primary power operation

(4) a red lamp for charger failure

(5) a green lamp for charger operation

(6) an equalization timer with dual scale to indicate 0 to 24 hours

(h) Remote indication or monitor control unit action shall be furnished on condition of:

(1) primary power failure

(2) power supply failure

(3) charger output voltage below 105% of nominal battery voltage

(4) battery terminal voltage below 90 ±2% of nominal

3.6.7.2 Glide Slope standby interface pweer requirements.- Standby power shall be continuously available. In addition, automatic operation of switching devices shall afford:

(a) disconnection of the battery from the load when terminal voltage drops to 80 ±5% of nominal

(b) disconnection of power supply when output exceeds 120 ±5% of nominal

3.6.7.3 Glide Slope battery enclosure requirements.- A noncorrosive battery box(s) shall be provided. This box shall contain the standby power supply batteries and shall be easily accessible. The battery box

shall be vented to the environment external to the Glide Slope equipment shelter to prevent accumulation of potentially explosive gasses. The battery box shall be constructed so as to prevent damage to the Glide Slope equipment shelter resulting from spilled electrolyte. A battery box located outside of the equipment shelter is permissible.

3.6.9.8 Glide Slope RF Cables

3.6.9.1 RF cables requirements.- The RF cables utilized in the Glide Slope subsystem shall be in accordance with paragraph 1-3.10.3 FAA-G-2100/1.

3.7 VHF Marker Beacon subsystem.

3.7.1 Marker Beacon general requirements.- A complete VHF Marker Beacon subysystem shall consist of three each of the following:

(a) One dual transmitter group with associated monitor and modulation equipment.

(b) One antenna group with monitor pickup devices and associated cabling, divider networks, connectors, hardware, etc., necessary to connect the transmitter to the antenna array.

(c) Standby battery power with appropriate housing.

(d) One equipment cabinet group as specified.

3.7.2 Marker Beacon operational requirements. The Marker Beacon subsystem shall provide information about the distance to the Category III ILS runway threshold of an aircraft engaging in approaches to, and landing at, airfields. Each Marker Beacon shall be capable of operating as an inner, middle or outer marker.

3.7.2.1 Operational radio frequency.- The design center transmitter output frequency shall be 75 MHz. All specified requirements shall be met at this output frequency. The output frequency shall be within ±0.005 percent of the 75 MHz over the service conditions.

3.7.2.2 Coverage.- The marker beacon field pattern is defined by the locus of points at which a standard calibrated aircraft installation set for "low" sensitivity, receives an audio signal in excess of 2 milliamperes while flying the limits of the Localizer course line, 150 microamperes either side of the Localizer centerline, or within ±10% of the limits of the major axis shown on Figure 1, whichever is less. The field strength at the limits of coverage specified in Figure 1 shall be 1.5 millivolts per meter. In addition, the field strength within the coverage area shall rise to at least 3.0 millivolts per meter. The field pattern shall meet the following requirements at antenna heights up to a maximum of 20 feet above ground elevation with the transmitter power output adjusted to .5 watts. (see figure 1.)

(a) When cut by horizontal plane, the pattern shall be an ellipse with its minor axis parallel to the course line. The ratio of the ellipse major axis to the minor axis shall be a minimum of 1.5 to 1.0.

(b) When cut by a vertical plane in the minor axis, the pattern shall be within 25 percent of the limits shown in figure 1. Minor axis coverage shall be measured on the Localizer course and descenting on the glide path. Coverage shall extend to an altitude of at least 3,000 feet above the station.

(c) The radiation shall be horizontally polarized.

(d) Major axis coverage shall be measured at the instrument approach procedures use altitude.

3.7.3 Marker Beacon transmitter group.

3.7.3.1 Marker beacon transmitters.- Dual transmitters shall be furnished for each marker beacon station, and each transmitter shall be complete with a modulator, means for generating the three tones, an identification keyer and front panel multimeter with a selector switch to display the d-c supply voltage, critical RF test points, modulation percentage, forward and reflected power and the monitor output for purposes of tuning-up and servicing the transmitter. A means of automatic and remotely controlled equipment changeover shall be provided. A crystal unit shall be furnished with each transmitter.

3.7.3.2 Transmitter performance.- The VHF Marker Beacon transmitter shall perform as follows over the service conditions.

(a) Carrier output.- The full rated carrier power output of the transmitter shall be not less than 2.5 watts over the service conditions as measured at a 50-ohm unbalanced resistive load terminating the transmitter output. After initial adjustment under normal test conditions, the power shall not vary more than ±25% over the service conditions.

(b) Power output adjustment.- It shall be possible to vary the output from full rated output to 10 percent or less of full rated output power.

(c) Modulation frequency.- The transmitter shall include built-in tone generating and modulating facilities so that it can be modulated at any power level in the range from .25 to 2.5 watts; from 0 to 97 percent by any of the following selectable frequencies.

(1) 400 Hz (Outer Marker)

(2) 1300 Hz (middle Marker)

(3) 3000 Hz (inner Marker)

(d) Modulation frequency tolerance.- Each modulation frequency shall be within ±1.5 percent of the design center frequency under normal test conditions. Variation of each modulation frequency shall not exceed 2.5 percent of the design center frequency under the service conditions. A control shall be provided for adjustment of the audio frequency to its nominal value.

(e) Modulation harmonic distortion.- The total harmonic distortion in the demodulated output shall not exceed 8 percent with rated power output and 98 percent modulation under the service conditions.

(f) Modulation stability with output power change.- After initial adjustment to 95 percent modulation, adjustment of output power over the available range shall not change the actual percent modulation more than 3 percent.

(g) Modulation stability over the service conditions.- After initial adjustment to 95 percent modulation with rated power output under normal test conditions, the modulation shall be 91 to 99 percent under the specified service conditions.

(h) Modulation indications.- A meter shall be provided to indicate percent modulation. The meter scale shall indicate 90 percent modulation at full scale left and 100 percent modulation at full scale right. The error in indicated percent modulation over the meter scale shall not exceed ±1 percent of the actual percent modulation over the full range of power output under normal test conditions. Under the specified service conditions, the error in indicated percent modulation shall not exceed ±5 percent of the actual percent modulation.

3.7.3.3 Marker Beacon identification requirements.- The transmitter shall include solid state electronic keying facilities. The design shall permit manual selection of the audio frequencies and keying circuits separately by means of programming jumpers or switches to provide modulating tones without interruption of the carrier.

(a) Modulating tones.- The modulating tone shall be provided and keyed as follows:

(1) The outer marker audio modulation frequency (400 Hz) shall be keyed to provide a continuous series of dashes.

(2) The middle marker audio modulation frequency (1300 Hz) shall be keyed to provide a continuous series of alternate dots and dashes.

(3) The inner marker audio modulation frequency (3000 Hz) shall be keyed to provide a continuous series of dots.

(b) Character timing.- The keyer shall provide character timing as follows:

(1)	Dot length:	0.125 second
(2)	Dash length:	0.375 second
(3)	Length of space between dots and dashes in a continuous series and within a code character.	0.125 second

(c) Keyer stability.- The keying rates shall remain within ±15 percent of the design center values under the service conditions. Keying pulses shall start without undesirable transients. Transient peaks due to keying shall not exceed 2 percent of the peak amplitude of the normal

audio frequency waveform at the modulator output. It shall be possible to locally select either keyed or unkeyed modulation or to remove all modulation from the transmitter without interrupting the carrier.

3.7.3.4 Equipment changeover and test requirements.- Changeover circuits shall be used to connect the antenna system to the principal or standby transmitter channel and monitors locally and on command of the indication and control unit.

3.7.4 Marker Beacon control monitoring.

3.7.4.1 Monitor pick-up antenna.- A monitor pick-up antenna shall be provided to sample the radiated marker beacon signal. The pick-up antenna location and gain characteristics shall meet the monitor requirements over the power output range of the transmitter.

3.7.4.2 Monitor requirements.- The local monitor shall cause a visible and audible alarm at the remote indication and control unit if any of the following conditions occur.

(a) The principal transmitter is replaced by the standby transmitter (dual system)

(b) The power output of the radiating transmitter drops below 50 percent of nominal

(c) Audio modulation or identification keying is not present

(d) Primary power to the site fails

(e) Battery charger fails

(f) Monitor is locally bypassed

(g) Subsystem is nonoperational

(h) The antenna is damaged to the extent that VSWR exceeds 2:1.

3.7.4.3 Monitor fail-safe design.- The monitor system specified herein shall be fail-safe such that failure of any parts of the monitor shall either result directly in an alarm condition, or as a minimum, shall not alter any alarm threshold level in the direction of tolerating greater deterioration of the transmitter output characteristics than permitted in the absence of such failures. For such parts as electronic or electromagnetic switching devices where it is not practical to provide fail-safe operation under both modes of failure (open circuit and short circuit), fail-safe protection shall be provided for the mode of failure having the higher probability.

3.7.4.4 Alarm controls.- Control(s) capable of varying the alarm threshold(s) shall be provided as necessary to meet the above monitoring requirements. These requirements shall be met with any transmitter output from rated power to 10 percent of rated power. It shall be possible to validate all alarm thresholds without external test equipment.

3.7.4.5 Alarm stability.- With alarm thresholds adjusted under normal test conditions to provide alarms, as stated above, the monitor shall indicate an alarm under the service conditions as follows.

(a) Carrier output -1.5 dB to -4.0 dB

(b) Modulation tone removed

(c) Unkeyed modulation

3.7.4.6 Alarm action.- When an alarm condition occurs during normal unattended operation, the monitor unit shall automatically shutdown the main transmitter and monitor within 5 seconds and transfer operation to the standby transmitter and monitor. In case of an alarm on the standby transmitter, it shall automatically shutdown this transmitter. Provisions shall be made for temporarily disabling this shutdown feature by minor wiring changes to the equipment. Restart of the station shall be accomplished by a manual reset. Provisions shall also be made for a remote restart capability such that momentary closure of a set of contacts at the remote monitor point will initiate the restart.

3.7.4.7 Normal-bypass switch/es.- The marker beacon station shall be furnished with a normal-bypass switch and a battery disconnect switch. The normal-bypass switch shall allow the temporary disabling of the automatic shutdown function for maintenance purposes and the battery disconnect switch shall enable the battery output voltage to be disconnected from the transmitting equipment. The switches shall be manually operated and shall be automatically returned to the normal position when the equipment is returned to service.

3.7.4.8 Abnormal condition panel requirement.- A panel shall be supplied at each Marker Beacon subsystem group, which shall provide visual indication of the following abnormal conditions:

(a) Primary power failure

(b) Battery charger failure

(c) Monitor locally bypassed

(d) Subsystem group not operating

(e) Monitor alarm

3.7.4.9 Remote abnormal indication.- The abnormal conditions shall be made available at a suitable telephone junction for line transmission to a remote control point. Abnormal power/environment (ABN P/E) indication shall be displayed in the case of commercial power loss or battery charger failure. Abnormal monitor (ABN MON) indication shall be displayed in the case of a monitor alarm due to unsatisfactory keying, modulation level or RF power output, or antenna VSWR of 2:1. A manual bypass of the monitor system at the Marker Beacon subsystem group shall cause the ABN P/E indicator at the remote indication and control unit to blink at a two Hz rate.

3.7.5 Marker Beacon antenna group.

3.7.5.1 Marker Beacon antenna system general requirements.- The transmitting antenna shall consist of single or multiple elements combined with an integral feed network and reflector(s) as required to meet the specified coverage requirements.

3.7.5.2 Marker Beacon antenna performance requirements.- In addition to providing the coverage requirements throughout the service conditions, the Marker Beacon subsystem antenna system shall be designed as follows:

(a) The VSWR of the transmitting antenna shall be less than 1.2:1.

(b) The Marker Beacon radiation shall be horizontally polarized.

3.7.6 Marker Beacon power.

3.7.6.1 Marker Beacon standby power requirements.- Standby power shall be furnished from a continuously engaged or floating battery power supply, which shall permit normal station operation for a period of 72 consecutive hours with battery temperature at 0 degress C during the specified service conditions. The battery shall be a lead-acid-unit (or units).

3.7.6.2 Marker Beacon power supply/battery charger unit requirement.- The battery charger unit shall:

(a) Maintain a float-voltage of 2.15 to 2.17V per cell with a maximum of 200 mV PP ripple with or without a battery attached. (Float voltage shall be maintained within ±5 percent over the load range.)

(b) Supply on demand an equalize voltage of 2.30 to 2.33V per cell with a maximum of 200 mV PP ripple. The equalize mode shall be disabled in the absence of a battery.

3.7.6.3 Marker Beacon power system indicator and control requirements.- The following display and control functions shall be provided for power system operation:

	Control/Indicator	Function
(a)	Switch, power on-off	Provide AC power input control to system
(b)	Switch, battery on-off	Provide battery disconnect
(c)	Lamp, primary power	Indicate current in charger output circuit
(d)	Lamp charger output	Indicate current in charger output circuit
(e)	Control, equalize	Set level for battery equalize mode

(f)	Control, float	Set regulator output
(g)	Control, undervolt	Set battery auto-disconnect level
(h)	Meter	Indicate power supply current and regulator output voltage

3.7.6.4 Marker Beacon battery enclosure requirements.- An insulated housing, separate from the transmitter housing shall be furnished to contain the batteries needed to satisfy the power requirements of the Marker Beacon subsystem and shall be designed for mounting on a platform. It shall provide adequate protection against damage caused by acid spillage. It shall have a hinged door to provide adequate weather protection for the batteries and shall be vented to permit the necessary air flow to prevent accumulation of potentially explosive gasses. A hasp shall be furnished for a padlock to preclude unathorized access to the equipment.

3.7.7 Marker Beacon interconnections

3.7.7.1 Signal cables.- Interconnecting cables shall be as specified for direct burial and adequate protection from hazard shall be provided.

3.7.7.2 RF cables.- The RF cables utilized in this subsystem shall be flexible, double shielded coaxial cables of 50-ohms nominal impedance and shall be in accordance with paragraph 1-3.10.3 of FAA-G-2100/1.

3.7.7.3 Telephone lines.- Telephone lines with single pair loop resistance not exceeding 2000 ohms, and interface equipment shall be used for the distribution of voice communications, alarm signals and control signals. A total of not more than 4 telephone line pairs shall be required for connection of each Marker Beacon subsystem group to the remote indicator and control unit.

3.7.8 Marker Beacon equipment cabinet.

3.7.8.1 Architectural and structural requirements.- The Marker Beacon transmitter equipment cabinet shall be suitable for pad mounting. Design conditions shall include:

(a) Covers.- The cabinet shall be provided with inner and outer front covers. The inner cover shall be top-hinged and secured by means of Dzus fasteners (or equivalent) along the bottom and side edges. A movable bar shall be provided to support the cover in a horizontal position as a rain shield. The hinges shall be detachable to permit complete removal of the cover when desired. When positioned as a rain shield, the cover shall not interfere with removal of modules or use of extender cards. The outer cover shall be removable by captive thumb screws. A hasp shall be furnished for attachment of a padlock to prevent unauthorized access to the equipment within the cabinet.

(b) Appearance.- The exterior of the cabinets should have a modern commercial or light industrial appearance. The appearance should reflect the precision and reliability of FAA activities and the utilitarian quality of public financed construction.

(c) Finish and color.- The exterior surface of the Marker Beacon cabinet shall be insignia white, color 17875 of FED-STD-595. Painting of all exterior surfaces shall be in accordance with FAA-STD-003.

(d) Materials and material application.- Materials of construction shall be suitable for the intended application considering the cabinet life, environmental service conditions, and transportation loads. The ultimate sites for these cabinets may range from coastal environments with salt atmosphere to mountainous areas. Provisions shall be made for prevention of corrosion; avoidance of unprotected fraying surfaces, moisture traps, and galvanic couples due to contact between dissimilar metals; and proper selection and application of protective finishes. The cabinet design shall keep maintenance to a minimum during the life of the cabinet with no required periodic maintenance inspection or activity normally necessary more often than once every year.

(e) Fire resistance.- Materials used for cabinet construction (hidden or exposed) shall be noncombustible or fire retardant. Noncombustible materials shall be determined in accordance with ASTM B 136 (Test for determining Noncombustibility of Elementary Materials). Materials which are inherently fire retardant or have received a fire retardant treatment shall produce a flame spread rating of not more than 25 when tested in accordance with ASTM E 84 (Surface Burning Characteristics of Building Materials). The fire retardant treatment shall not be subject to degradation due to weathering or custodial operations such as cleaning, washing, etc. Plastic materials (including foam insulation and sandwich panel rigid foam) shall be processed to impart self-extinguishing characteristics to the material when tested in accordance with ASTM D 635 and ASTM D 1962 (Flammability of Rigid Plastics over 0.127 CM in Thickness and Flammability of Plastic Foams and Sheeting, respectively).

(f) Heat transmission.- There is no heat transmission value for marker beacon cabinets as the intent for this enclosure is to provide shelter from inclement weather only.

(g) Foundation design.- The contractor shall design and prepare standard foundation construction drawings and specification suitable for Government contracts with small general contractors at field installation sites. An allowable soil bearing pressure of 3,000 pounds per square foot shall be assumed for the design, with a 48" maximum frost penetration.

3.7.8.2 Marker Beacon equipment cabinet environmental control requirements.- The Marker Beacon equipment cabinet shall be of double wall construction, and shall be vented to provide convection cooling of the equipment while simultaneously providing protection against rain and screening against insects. The inner cabinet shall be vented as required for adequate convection cooling

with RF screening as required to meet equipment performance requirements. Air conditioning, heating and ventilating equipment (if required) shall be in accordance with Specification FAA-C-2256.

3.7.8.3 Marker Beacon equipment cabinet electrical requiremnts.-

(a) General.- Electrical equipment shall be designed, sized, arranged, and furnished to accommodate all of the electrical power requirements of a complete ILS Marker Beacon facility. The design shall be in accordance with the National Electrical Code and Specification FAA-C-1217. In the event of conflict, Specification FAA-C-1217 shall govern.

(b) Distribution system.- The Government will provide 120/240V, 60 Hz single-phase, three-wire, underground commercial power service to the site. The cabinet electrical distribution system shall commence with the incoming service conduit and conductors as they enter the cabinet floor or wall if applicable and extend throughout the facility, including the antenna system and support tower. Spare electrical capacity of not less than 50% of the design load shall be provided in the distribution panelboard capacity and distribution wiring. Short circuits and overloads shall be cleared at the lowest possible level in the system via proper coordination of circuit breakers of fuses or both.

(c) Outlets.- A 120 volt AC, single-phase, 20-ampere, duplex outlet shall be installed and wired inside of the inner cabinet of the equipment cabinet.

3.7.8.4 Equipment cabinet environmental requirements.- The cabinets and equipment therein shall sustain the maximum stress imposed by the ambient service conditions specified without permanent deformation damage or degradation of operation.

3.8 Remote Indication and Control Subsystem

3.8.1 Remote Indication and Control general requirements.- The Category III ILS design shall include a remote indication and control subsystem that when interfaced with the Localizer Glide Slope, and Marker Beacon subsystems, provides visual and aural indications of the operational status of the ILS and is capable of selected control functions. The remote indication and control equipment shall be designed for installation in a standard 19-inch relay rack or dest top cabinet. Panel height shall be as small as possible and ir any case shall not exceed 14 inches and depth shall not exceed 9 inches. Power requirements shall not exceed 250 watts from a 60 Hz 120 volt single phase three wire source.

3.8.2 Remote indication and control performance.- The remote indication and control subsystem is intended for installation in a remote control location with a (slave) indication display unit intended for installation at the principal maintenance facility location. The (slave) indication display unit shall function in parallel with the remote indication and control unit with the exception that the slave unit shall not require any of the control functions. These equipments shall provide the following functions:

(a) Visual indications of the status of the Localizer, Glide Slope, and Marker Beacon subsystem by the use of green, amber and red lights. The green light indicates that the principal transmitter is radiating, the amber light indicates the standby transmitter is radiating, and the red light indicates neigher transmitter is radiating.

(b) An aural and visual indication of a system abnormal monitor (alarm) condition and of an abnormal power environmental condition.

(c) Visual indicators of system Category III status (green) and of a system Category I status (amber).

(d) Alarm silence

(e) Remote cycle switch for control of the Localizer subsystem, Glide Slope subsystem and three Marker Beacons (remote control only).

(f) Dimmer control for all indicating lights

(g) Interphone service with the Localizer subsystem, Glide Slope subsystem and three Marker Beacons (remote control unit only).

(h) Aural monitoring of the 1020 Hz Localizer identification signal (remote control unit only).

(i) Inclusion of one spare channel.

(j) Bulb test to check all indicating lights.

3.8.3 Fault and control modules.- The remote indication and control subsystem shall include six (6) interchangeable fault and control modules for each of the two display units, each having the same monitoring functions. Five modules shall be utilized to service the Localizer, Glide Slope and three (3) Marker Beacon units, while the sixth module shall function as a spare unit. The functional features of each module is specified as follows:

(a) Visual indication of the operational status of the subsystem transmitting equipment by the use of "green normal," "amber operational standby," and "red abnormal" indicating lights. When a transmitter status changes to standby or off, an audible alarm shall sound until silenced by depressing the alarm silence.

(b) The capability to start or stop the function of the subsystem transmitting equipment as well as the capability to select either the main or standby transmitter equipment for operational use (remote control only).

(c) Visual indication of the operational status of the subsystem by the use of an amber light to indicate remote monitor bypass function and monitor alarm. When a monitor alarm is indicated an audible alarm shall sound until silenced by depressing the alarm silence.

(d) Visual indication of the operational status of the subsystem by the use of an amber light to indicate a prime power, standby power and/or environmental temperature alarm. When this alarm is indicated, an audible alarm shall sound until silenced by the alarm silence.

3.8.4 Display panel design.- The display panel design shall be organized into the following functional zones:

(a) Fault and control modules. The six identical fault monitor modules shall be provided and labeled:

(1) Localizer

(2) Glide Slope

(3) Inner Marker

(4) Middle Marker

(5) Outer Marker

(6) Spare

(b) Status.- Facility performance Category I and III indicator lamps with dimmer, continuous audible signal for performance category changes with a loudness control, farfield monitor action time delay, power on-off control and a bulb test switch shall be provided in the status zone.

(c) Intercom.- A telephone handset and cradle with six lighted loop select switches labeled LOC, GS, IM, MM, OM, SP, respectively, shall be provided in the intercom zone. This zone shall be blank on the (slave) indication display unit.

3.8.5 ILS performance characteristics.- The remote indication and control subsystem shall provide logical determination of ILS performance status. Inputs from all operating subsystems that comprise the ILS shall be logically combined to produce:

(a) Category III status indication

(b) Category I status indication

(c) An audible signal on change of status

3.8.5.1 Category III status indication.- The Category III status shall be illuminated only if the following operational conditions are positive:

(a) Localizer principal transmitter is on the air

(b) Localizer standby transmitter is available

(c) Two of three Localizer far field course monitors indicate that the course position parameter is within Category III tolerance limits, subject to an adjustable decision delay at the display panel of up to 30 seconds.

(d) Localizer monitor channel inhibit not present

(e) Localizer station battery terminal voltage above preset level

(f) Glide Slope principal transmitter is on the air

(g) Glide Slope standby transmitter is available

(h) Glide Slope monitor channel inhibit not present

(i) Glide Slope station battery terminal voltage above preset level

(j) Outer marker beacon operating without alarm

(k) Middle marker beacon operating without alarm

(l) Inner marker beacon operating without alarm

(m) Unless input is bypassed, distance measuring equipment (DME) or other optional conditions operating within tolerance

(n) Localizer power/environmental alarm absent or within preset alarm delay at the display panel.

(o) Glide Slope power/environmental alarm absent or within preset alarm delay at the display panel.

3.8.5.2 Cateogry I status indication.- The Category I status shall be illuminated only if all the following conditions are positive:

(a) Either the principal or standby transmitter at the localizer station is on the air, provided that no monitor channel inhibit exists.

(b) Either the principal or standby transmitter at the Glide Slope station is on the air, provided that no monitor channel inhibit exists.

(c) The Category III indicator is off.

(d) Outer marker beacon operating without alarm.

(e) Middle marker beacon operating without alarm.

(f) Inner marker beacon operating without alarm.

3.8.6 Audible status change alarm.- An audible alarm shall occur when the system is downgraded. The alarm shall be continuous with a manual silence capability at the status display panel. This alarm shall be distinct from that generated from the fault and control modules (3.8.3 a, c, and d). The alarm shall also be adjustable for loudness.

3.8.7 Time delay requirements.- Two independent programmable counters shall be provided to delay power/environmental abnormal alarm inputs from Localizer, Glide Slope and Marker Beacon subsystems before causing the ILS to be downgraded from Category III to Category I. Each delay circuit shall be settable in ten-minute increments to a maximum of two-hours fifty-minutes

by the use of internal connection. Automatic counter reset shall occur if the alarm stimulus is removed for a period of fifty milliseconds.

3.8.7 Intercommunication requirements.- Intercom circuitry shall be provided to allow voice communication between all subsystems of the ILS. In addition, provision shall be made for the audible monitoring of the Localizer identification tone and keying. Circuit selection and latching shall be provided in conjunction with the intercom receiver and select switches.

3.9 Maintenance Monitor subsystem

3.9.1 Maintenance Monitor general requirements.- The Category III maintenance monitor subsystem shall consist of the following equipment units:

(a) Status display panel unit.- located in the principal maintenance facility.

(b) Localizer maintenance monitor unit.- located in Localizer shelter.

(c) Localizer far field monitor maintenance monitor unit.- located in far field monitor enclosure.

(d) Glide Slope maintenance monitor unit.- located in Glide Slope shelter.

These equipment units shall form an integrated subsystem that will have the capability to alert the principal maintenance facility of impending failure or partial determination of ILS equipment, prior to this equipment exceeding its operational limits.

3.9.2 Maintenance monitor equipment performance.- The maintenance monitor remote equipment units shall sample analog voltage outputs and/or switch closures to determine the maintenance condition of the various subsystems that comprise the Category III ILS. These parameters shall be independently compared with predetermined voltage levels or conditions that shall give advance indication that one or more of the selected parameters has exceeded its preset value. The monitor sensing circuitry for each parameter shall be individually adjustable to cover nominal 75 percent $\pm$50 percent of the parameter alarm limits. Provisions shall be made to display the pre-alarm indication at the status display panel unit that will be located in the principal maintenance facility area.

3.9.3 Maintenance monitor display

Status panel.- The maintenance monitor display status panel shall be divided into zones that indicate the pre-alarm conditions of the Localizer subsystem, the Localizer far field monitor and the Glide Slope subsystem and shall contain an on/off control. Table 3, Maintenance Monitor Status Panel Display, indicates the minimum display requirements that shall be provided in the design of the status display panel unit. Indicator lamps

shall be operated by suitable lamp driver circuits and power source contained within the status panel. A voltage shall be returned through relay contacts at the remote monitor facilities for lamp driver control, and shall be arranged to indicate fault on all lines in the event of power failure or power off conditions existing at the remote facility. A power off condition at the status panel shall in no way influence the equipment that is being monitored. The maintenance monitor display status panel shall be suitable for mounting in a standard 19-inch relay rack or desk top cabinet. Power requirements shall not exceed 200 watts from a 60 Hz, 120 volt single phase three wire circuit.

TABLE 3. MAINTENANCE MONITOR STATUS PANEL DISPLAYS

Source	Monitor Channel or Function	Paramaters Monitored	Indicator
Localizer Subsystem	Integral Course I	RF, SDM, DDM	Amber Light in Prealarm
	Integral Course II	RF, SDM, DDM	Amber Light in Prealarm
	Integral Course III	RF, SDM, DDM	Amber Light in Prealarm
	Integral Sensitivity I	DDM	Amber Light in Prealarm
	Integral Sensitivity II	DDM	Amber Light in Prealarm
	Integral Sensitivity III	DDM	Amber Light in Prealarm
	Integral Clearance I	RF, SDM, DDM	Amber Light in Prealarm
	Integral Clearance II	RF, SDM, DDM	Amber Light in Prealarm
	Integral Clearance III	RF, SDM, DDM	Amber Light in Prealarm
	Identification I	Site ID	Red Light-Alarm in Absolute
	Identification II	Site ID	Red Light-Alarm in Absolute
	Identification III	Site ID	Red Light-Alarm in Absolute
	Clearance Course I	RF, SDM, DDM	Amber Light in Prealarm
	Clearance Course II	RF, SDM, DDM	Amber Light in Prealarm
	Standby Course	RF, SDM, DDM	Amber Light in Prealarm
	Standby Sensitivity	DDM	Amber Light in Prealarm
	Standby Clearance	RF, SDM, DDM	Amber Light in Prealarm
	Standby Identification	Site ID	Red Light-Alarm in Absolute
	Temperature	Shelter Temperature	Amber Light in Prealarm
	Battery	Battery Voltage	Amber Light in Prealarm
Localizer Far Field Monitor	Far Field Course I	SDM, DDM	Amber Light in Prealarm
	Far Field Course II	SDM, DDM	Amber Light in Prealarm
	Far Field Course III	SDM, DDM	Amber Light in Prealarm
	Battery	Battery Voltage	Amber Light in Prealarm
Glide Slope Subsystem	Integral Course I	RF, SDM, DDM	Amber Light in Prealarm
	Integral Course II	RF, SDM, DDM	Amber Light in Prealarm
	Integral Course III	RF, SDM, DDM	Amber Light in Prealarm
	Integral Sensitivity I	DDM	Amber Light in Prealarm
	Integral Sensitivity II	DDM	Amber Light in Prealarm
	Integral Sensitivity III	DDM	Amber Light in Prealarm
	Integral Clearance I	RF, SDM, DDM	Amber Light in Prealarm
	Integral Clearance II	RF, SDM, DDM	Amber Light in Prealarm
	Integral Clearance III	RF, SDM, DDM	Amber Light in Prealarm
	Near Field Course I	RF, SDM, DDM	Amber Light in Prealarm
	Near Field Course II	RF, SDM, DDM	Amber Light in Prealarm
	Near Field Course III	RF, SDM, DDM	Amber Light in Prealarm

TABLE 3. MAINTENANCE MONITOR STATUS PANEL DISPLAYS (continued)

Source	Monitor Channel or Function	Paramaters Monitored	Indicator
	Standby Course	RF, SDM, DDM	Amber Light in Prealarm
	Standby Sensitivity	DDM	Amber Light in Prealarm
	Standby Clearance	RF, SDM, DDM	Amber Light in Prealarm
	Temperature	Shelter Temperature	Amber Light in Prealarm
	Battery	Battery Voltage	Amber Light in Prealarm

3.9.4 Localizer maintenance monitor requirements.- The Localizer subsystem maintenance monitor unit shall sample the analog voltage outputs and/or switch closures from selected monitor channels, and, by independent comparison with predetermined and adequately adjustable voltage levels or conditions, give advance indication that one or more of the selected parameters has exceeded preset values, nominally 75 percent of alarm limits. Provision shall be made for remote display of indicated prealarm conditions. A minimum of 39 parameters shall be monitored at the Localizer subsystem. Monitor channel outputs shall be processed for DDM SDM and RF power prealarm levels and summed in a logical "OR" to present a single prealarm indication for each monitor channel. Exceptions to the above shall be that course width monitors are processed DDM only, and ID monitors shall indicate actual alarms. The status display panel shall be provided with, as a minimum, the following groups of lamp indications:

(a) A group of three lamps, numbered 1, 2, 3.

(1) Course (ON GSE) position No. 1 (RF + SDM + DDM)

(2) Course (ON CSE) position No. 2 (RF + SDM + DDM)

(3) Course (ON CSE) position No. 3 (RF + SDM + DDM)

(b) A group of three lamps, numbered 1, 2, 3.

(1) Course (OFF CSE) No. 1 (DDM)

(2) Course (OFF CSE) No. 2 (DDM)

(3) Course (OFF CSE) No. 2 (DDM)

(c) A group of three lamps, numbered 1, 2, 3.

(1) Clearance (OFF CSE) No. 1 (RF + SDM + DDM)

(2) Clearance (OFF CSE) No. 2 (RF + SDM + DDM)

(3) Clearance (OFF CSE) No. # (RF + SDM + DDM)

(d) A group of two lamps, numbered 1, 2.

(1) Clearance (ON CSE) position No. 1 (RF + SDM + DDM)

(2) Clearance (ON CSE) position No. 2 (RF + SDM + DDM)

(e) A group of three lamps, numbered 1, 2, 3.

(1) Identification No. 1 (SITE ID)

(2) Identification No. 2 (SITE ID)

(3) Identification No. 3 (SITE ID)

(f) A group of four lamps, functionally named.

(1) Standby course position (RF + SDM + DDM)

(2) Standby course width (DDM)

(3) Standby clearance (RF + SDM + DDM)

(4) Standby ID (SITE IDENTIFICATION)

(g) A single lamp monitoring battery voltage.

(h) A single lamp monitoring temperature.

3.9.5 Far field monitor maintenance monitor requirements.- The Localizer far field monitor unit shall sample the analog voltage and/or switch closure from the three monitor channels and by independent comparison with predetermined and adequately adjustable voltage levels give advance indication that one or more of the selected paramaters has exceeded preset values, nominally 75 percent of alarm limits. A minimum of six parameters shall be monitored at the far field monitor facility. Monitor channel outputs shall be processed for DDM and SDM prealarm levels and summed in a logical "OR" to present a single prealarm indication for each monitor channel. The status display panel unit shall be provided with, as a minimum, the following group of lamp indications:

(1) Far field course No. 1 (DDM + SDM)

(2) Far field course No. 2 (DDM + SDM)

(3) Far field course No. 3 (DDM + SDM)

(4) Battery voltage

3.9.6 Glide Slope Maintenance Monitor requirements.- The Glide Slope subsystem maintenance monitor unit shall sample the analog voltage outputs and/or switch closures from selected monitor channels, and, by independent comparison with predetermined and adequately adjustable voltage levels or conditions, give advance indication that one or more of the selected parameters has exceeded preset values, nominally 75 percent of alarm limits. Provision shall be made for remote display of indicated prealarm conditions. A minimum of 38 parameters shall be monitored at the Glide Slope subsystem. Monitor channel outputs shall be processed for DDM, SDM and RF power prealarm levels, and summed in a logical "OR" to present a single prealarm indication for each monitor channel. Exceptions to the above shall be that course width monitors are processed for DDM only and clearance monitors apply to capture effect configuration only. The status display panel unit shall provide, as a minimum, the following groups of lamp indications:

(a) A group of three lamps, numbered 1, 2, 3.

(1) Course position No. 1 (RF + SDM + DDM)

(2) Course position No. 2 (RF + SDM + DDM)

(3) Course position No. 3 (RF + SDM + DDM)

(b) A group of three lamps, numbered 1, 2, 3.

(1) Course width No. 1 (DDM)

(2) Course width No. 2 (DDM)

(3) Course width No. 3 (DDM)

(c) A group of three lamps, numbered 1, 2, 3.

(1) Clearance No. 1 (RF + SDM + DDM)

(2) Clearance No. 2 (RF + SDM + DDM)

(3) Clearance No. 3 (RF + SDM + DDM)

(d) A group of three lamps, numbered 1, 2, 3.

(1) NFM course position No. 1 (RF + SDM + DDM)

(2) NFM course position No. 2 (RF + SDM + DDM)

(3) NFM course position No. 3 (RF + SDM + DDM)

(e) A group of three lamps, numbered 1, 2, 3.

(1) Standby course position (RF + SDM + DDM)

(2) Standby course width (DDM)

(3) Standby clearance (RF + SDM + DDM)

(f) A single lamp, monitoring battery voltage.

(g) A single lamp monitoring temperature.

3.9.7 Maintenance monitor subsystem environmental requirements.- The maintenance monitor subsystem and all equipment that comprise this subsystem shall be designed and manufactured to satisfy the specified environmental service conditions.

4. QUALITY ASSURANCE, RELIABILITY, MAINTAINABILITY AND FAIL-SAFE PROVISIONS

4.1 General.- The contractor shall provide and maintain a quality control program in accordance with FAA-STD-016, and the quality assurance provisions specified in section 1-4 of Specification FAA-G-2100/1 shall apply.

The contractor shall demonstrate by calculations and analytical evaluation that his proposed mechanical, structural and electronic equipment will meet the specified reliability, maintainability and fail-safe requirements. The design evaluation conducted by the contractor shall be consistent with the latest available reliability and maintainability engineering procedures. MIL-STD-785 and MIL-STD-470, respectively. The contractor shall await approval of the final design by the Government prior to proceeding with the final assembly of the equipment. The performance evaluation to be conducted by the Government shall be based on statistical techniques requiring the actual operation of the equipment in an ambient operational environment for a period of time sufficient to assure that the Instrument Landing Systems furnished meet all specified requirements. This evaluation shall be conducted in accordance with a test program prepared by the contractor and submitted to the Government for review and approval.

4.2 Quality Assurance Plan.- The contractor shall prepare a Quality Assurance Plan that documents the quality assurance activities, events, and procedures that will be implemented by the contractor during the design, fabrication and testing phases that lead to the delivery of the Category III ILS. A draft Quality Assurance Plan shall be delivered to the FAA to be reviewed prior to approval of the plan. The contractor shall receive approval from the Contracting Officer to implement the Quality Assurance Plan prior to proceeding with the manufacture or test of any equipment.

4.3 Quality program requirements.- The contractor shall provide and maintain a quality control program which fulfills the requirements of FAA-STD-016 and Specification MIL-I-45208, Inspection Systems Requirements. The contractor's quality control program shall be scheduled and controlled plan of events integrating all necessary design reviews, and purchasing activities, and shall include those necessary to develop procedures that will be utilized in the performance of evaluation that are based on statistical techniques that require comprehensive evaluation, inspection and test of ILS. The contractor shall demonstrate by actual operation of the equipment for a sufficient period of time to assure that specification requirements have been satisfied. Prior to any fabrication of the equipment, equipment subsystem tests, or operational demonstrations, it will be required that the contractor shall deliver to the FAA, the results of any analytical evaluation of subcontract activities, fabrication, processes, manufacture, assembly, acceptance testing, packing, and shipping. The contractor shall perform the inspection and testing required to substantiate product configuration and conformance to drawings, specifications and contract requirements. The design evaluation phase shall be consistent with the latest available reliability engineering system, subsystem, or equipment units design to demonstrate that the proposed design has the inherent capability of meeting the ILS Specification. The contractor shall receive final design approval from the Contracting Officer prior to proceeding with the final assembly of the equipment.

4.4 Reliability program plan.- The contractor shall design and establish equipment reliability capabilities through a program plan performed in accordance with MIL-STD-785 and MIL-HDBK-217. A reliability analysis shall be submitted containing the following as a minimum:

(a) A reliability block diagram of the equipment indicating all redundancies, series, elements, voting logic, etc.

(b) Failure rates for each element of the equipment where an element is defined as the lowest level of assembly for which failure rates are available.

(c) References of all failure rate data and modification factors used to account for environmental conditions. Justification of these factors must be based on engineering analysis.

(d) Systems failure modes must be identifeid for each ILS station.

(e) An estimate of the equipment MTBF shall be made, based on the above requirements.

(f) An estimate of the ILS facility reliability shall be made based on the above requirements.

(g) All assumptions concerning the reliability analysis must be documented and justified.

4.5 Reliability demonstration plan.- Using Military Standard 781, the contractor shall design and implement a reliability demonstration test plan such that the probability of the FAA accepting a system that does not meet a minimum acceptable reliability level of 833 hours for localizer and 1333 hours for Glide Slope shall not exceed 0.10. Test Plan V of MIL-STD-781 using a sample of two complexed systems shall be used for assurance of the specified equipment MTBF reliability requirements.

4.6 Maintainability demonstration plan.- The contractor shall design plans whereby fault simulation for corrective maintenance tasks shall be performed by the introduction of faulty parts, deliberate misalignment (bugging), etc., as specified in MIL-STD-471, Maintainability Demonstration. A minimum of fifty (50) stratified (bugged) samples are required for developing time-to-repair data. The contractor can assume that the time-to-repair data fits a log normal distribution. The time-to-repair data should not include logistic delay, i.e., repairmen, parts and tools are available. The contractor shall demonstrate System Maintainability (corrective maintenance) by applying Test Method I, Test Plan B-2, and OC Curve, Figure B-2 of 3 MIL-STD-471 using the fault simulation time-to-repair data.

4.7 Fail-safe demonstration plan.- The supplier shall provide a test plan to demonstrate that the fail-safe requirements are met. The plan shall provide for demonstrating, as a minimum, that failure of any part of the monitor shall either:

(a) result directly in an alarm condition

(b) not alter any alarm threshold in the direction of tolerating greater deterioration of the system performance characteristics than permitted in the absence of such failures

and failure of any part of the control unit shall either:

(a) result in automatic shutdown of the associated facility

(b) not inhibit the control unit from accomplishing these functions in the event of a monitor alarm.

The above criteria shall be demonstrated during the collection of time-to-repair data by observing and recording the system's behavior to the deliberate introduction of faulty parts and/or the misalignment or both of the system in which a hazardous condition can occur and if necessary to continue to introduce faulty parts and/or misalign (bug) the system or both so as to demonstrate a particular fail-safe characteristic that was not demonstrated during the collection of time-to-repair data. The contractor will assure the FAA that all potential modes of hazardous failure have been studied and satisfy the fail-safe requirements.

4.8 Demonstration plan evaluation.- The ILS demonstration plans formulated and implemented by the contractor with the cooperation of the FAA shall be subjected to continuous evaluation by the contractor and FAA during the implementation phase.

4.9 Workmanship and inspection.- The equipment and components manufactured and assembled to form the groups of equipment and subsystems of the ILS, shall satisfy those workmanship standards that are necessary and required to satisfy all performance specifications, reliability requirements, and environmental requirements detailed in this specification. The equipment to be delivered will be inspected for conformance to the fabrication drawings and specifications and the requirements of this specification. The inspection shall include, but not be limited to, workmanship, dimensions (including flatness and squareness), connections, missing parts, damaged materials, inoperative parts, damaged finishes, and parts not easily operable. All electrical wiring and equipment shall be inspected and tested in accordance with FAA-C-1217, and the National Electric Code. All tests and inspections shall be witnessed by authorized representative of the Government. The contracting officer shall be notified at least ten (10) work days in advance of each test or series of tests.

4.10 Testing.- The contractor shall submit a test plan in accordance with FAA-STD-016, to insure that the proper testing that is applied to the Category III ILS, subsystems, equipment groups and items of equipment to demonstrate that the specifications are satisfied. The contractor shall be responsible for overall coordination of the testing effort so as to prevent duplication and to insure that there are no serious omissions. If any portion of the program is subcontracted, the subcontractor shall be responsible to the contractor for their portion of the task.

The contractor shall be responsible for supervising the formulation and implementation of the test plans, procedures and data reporting system.

The contractor shall specify the methods of collecting data as well as informing the FAA as to the progress of the test programs. The contractor shall submit a test schedule that indicates the major milestones in accomplishing test program.

The test program shall demonstrate that all operational parameters and equipment specifications have been satisfied. The test program will cover the following criteria:

(a) Systems tests

(b) Subsystem tests

(c) Equipment group tests

(d) Equipment item tests

(e) Equipment modules tests

(f) Component tests

(g) Material tests

(h) Environmental tests

(i) Reliability tests

(j) Availability demonstration

(k) Maintainability demonstration

(l) Fail-safe demonstration

The contractor shall document the formulation and implementation phases of the test and demonstration program. The documentation for the formulation phase shall be submitted with the contractor's proposal for the ILS Ground Equipment as a separately bound document and shall include the following:

(a) The contractor's proposed demonstration plan management organization.

(b) A complete description of the demonstration test plans, analytic models and reliability analysis.

(c) A complete description of the data reporting system with a description and samples of data reporting forms.

(d) A milestone chart and planned work schedule indicating the time required to demonstrate the various phases of the demonstration requirements.

Documentation for this phase shall consist of the following:

(a) Progress Reports shall include milestone charts showing the planned work schedule and work completed. The contractor's demonstration plan management must ensure that these reports are consistent with the objectives and plans described in the Formulation Phase of the demonstration test plan program.

(b) Final Report covering the completed contract effort shall contain as a minimum:

(1) Data collected.

(2) Factors which influence data.

(3) Analysis of the data (data reduction techniques used, use of data by the analytic models).

(4) Results of the tests and/or demonstration.

The contractor or his authorized representative shall sign the original tracings of all drawings and the first page of all specifications, design calculations, or similar documents under the contractor's printed name and over the affixed replica of his professional seal or his registration certification number including the state or jurisdiction of issue.

5. PREPARATION FOR DELIVERY

5.1 Items to be delivered.- Preservation and packaging of items to be delivered in a shelter shall be in accordance with paragraph 3.7.1.2, (Level C) of MIL-E-17555 and packing of these items shall be in accordance with paragraph 3.7.2.2 (Level C) of MIL-E-17555.

5.2 Preservation and packaging.- Preservation and packaging of items to be delivered separately from the shelter shall be in accordance with Specification (MIL-E-17555, Level A, Method II).

5.3 Packing.- Packing of items to be delivered separately from the shelter shall be in accordance with Specification MIL-E-17555, Label B. No more than one set of equipment and associated items shall be packed in each shipping container.

5.4 Marking.- Each package and shipping container shall be durably and legibly marked with the following information:

Name of Item and FAA Type Designation

Serial Number(s)

Quantity

Contract Number

Federal Stock Number

Gross Weight of Container

Manufacturer's Name

6. NOTES.

* * * * *

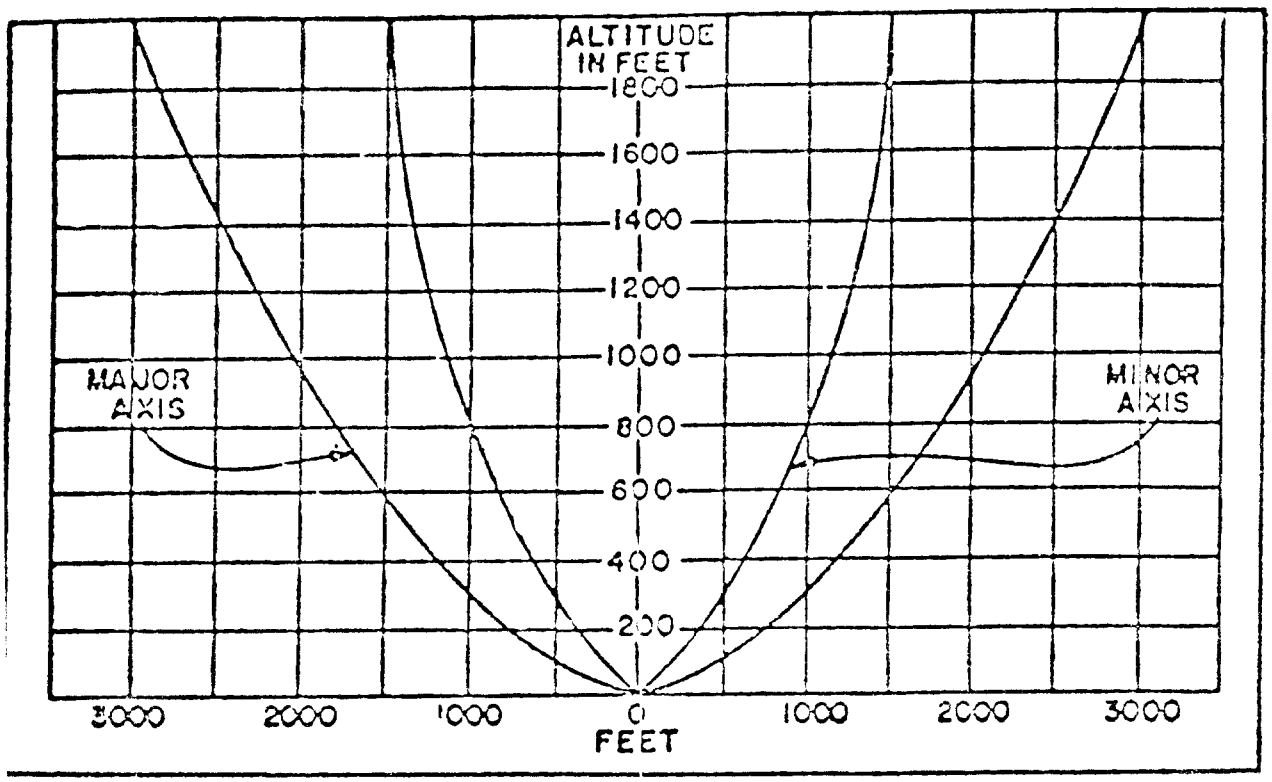
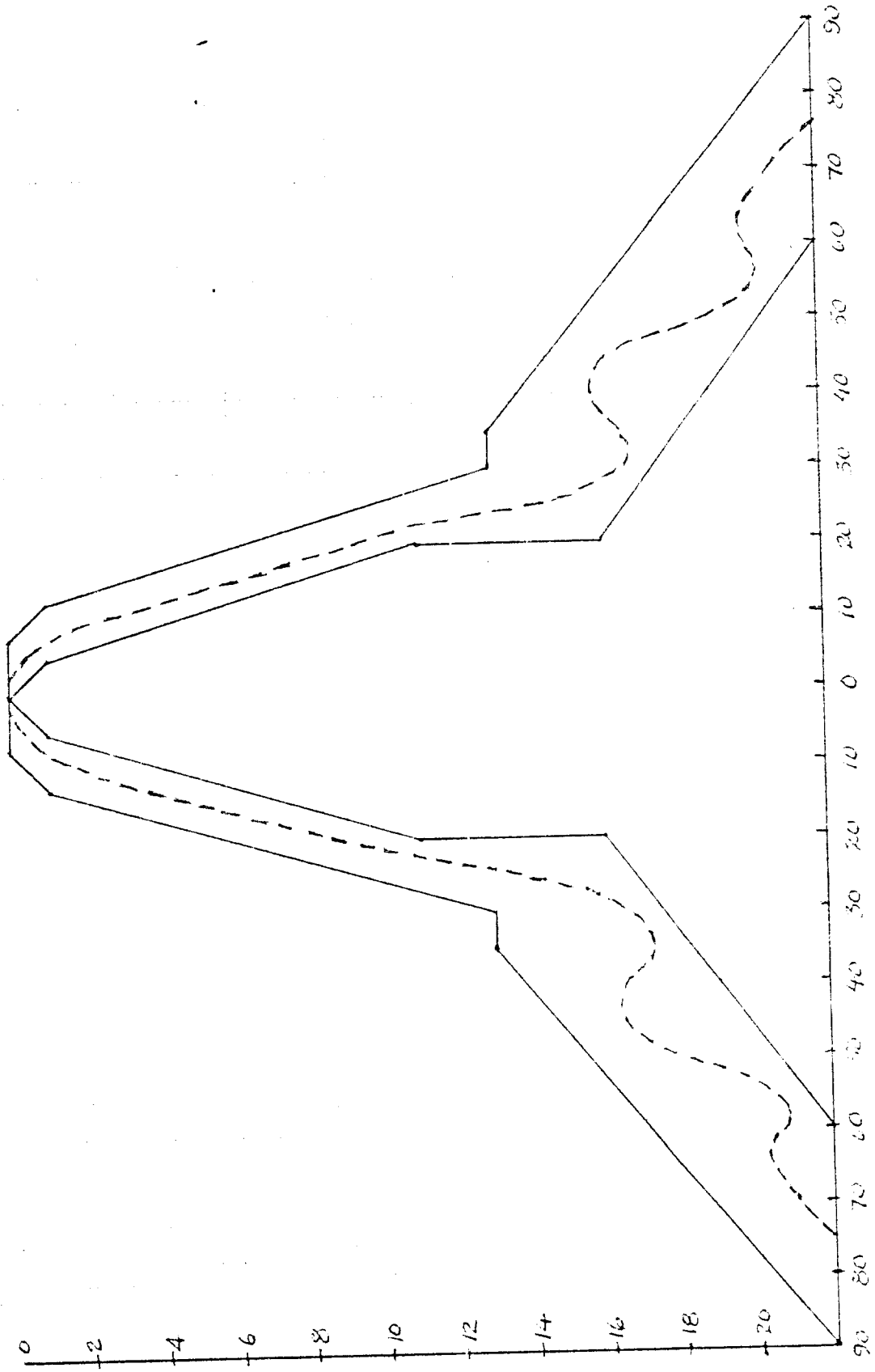
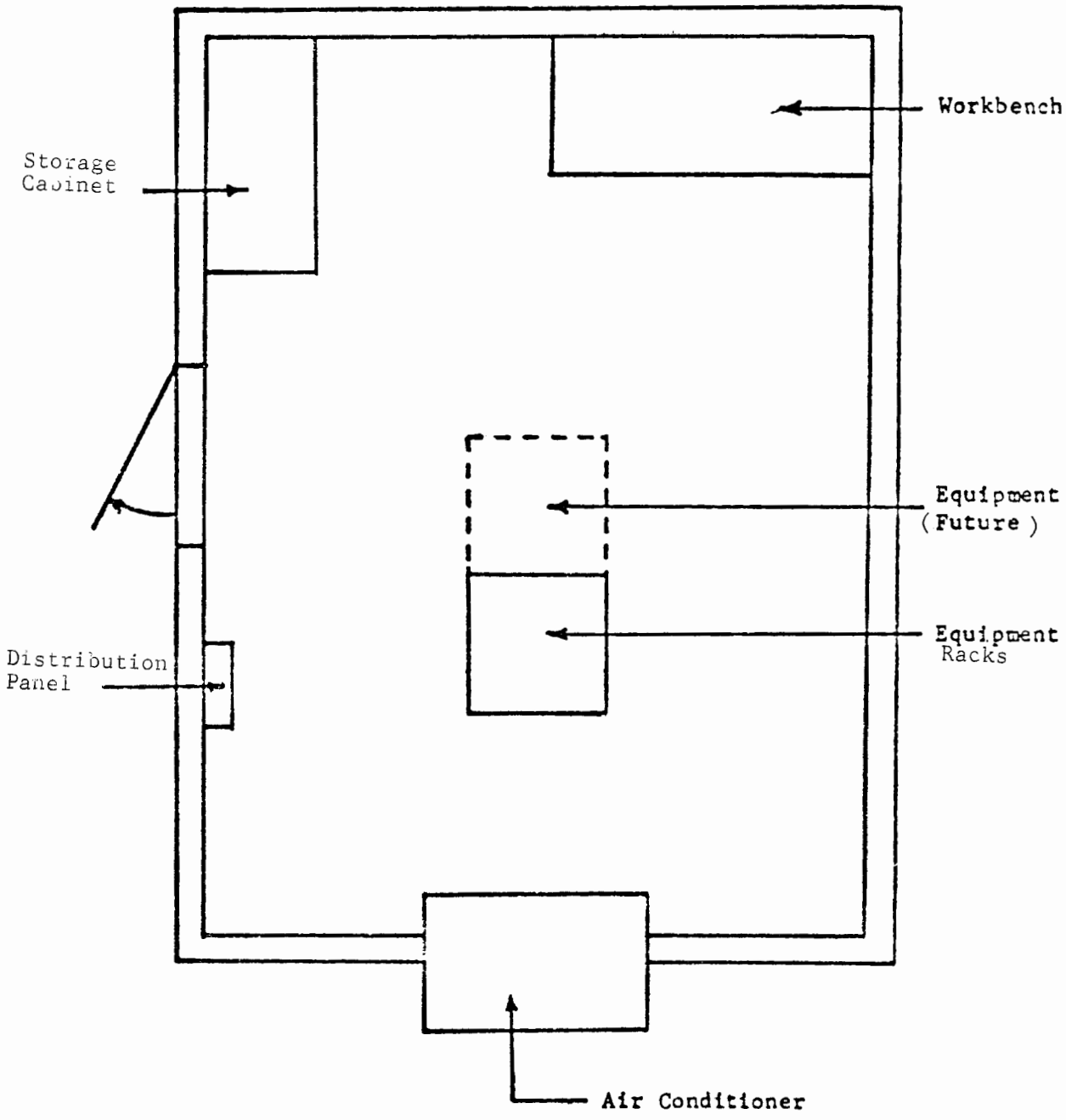

ALTITUDE IN FEET
1800
1600
1400
1200
1000
800
600
400
200
MAJOR AXIS
MINOR AXIS
3000
2000
1000
0
1000
2000
3000
FEET

FIGURE 1



Horizontal free space radiation pattern for antenna array.

Figure 2



LOCALIZER/GLIDE SLOPE BUILDING

FIGURE 3

TABLE OF CONTENTS